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REPORT NO T95-6

NUTRIENT INTAKES AND NUTRITIONAL STATUS OF SOLDIERS CONSUMING THE MEAL, READY-TO-EAT (MRE XII) DURING A 30-DAY FIELD TRAINING EXERCISE

U S ARMY RESEARCH INSTITUTE
OF
ENVIRONMENTAL MEDICINE
Natick, Massachusetts

January 1995

UNITED STATES ARMY
MEDICAL RESEARCH & MATERIEL COMMAND

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13. ABSTRACT *(Maximum 200 words)*

This study assessed soldiers' ability to meet nutritional needs and maintain performance while solely consuming the MRE in a field environment for 30 days; soldiers received only MREs (MRE grp;n=35) or 2 A-ration meals & 1 MRE daily for 30 days (control grp; n=32). Energy consumption was lower and weight loss was greater in the MRE grp than the control grp. The greatest weight loss occurred in soldiers intentionally trying to lose weight in the MRE grp. Non-dieting MRE grp soldiers lost < 2 lbs/wk and had lost 3.1% of initial body weight by day 30 of the study. Weight loss was primarily due to a reduction in body fat stores. The MRE grp consumed only 55% of energy provided, producing an energy deficit of 600 kcal/day below the actual requirement of 3000-3200 kcal/day. The MRE grp ate <MRDA for calcium, B_{12}, zinc, iron, magnesium, and folacin. Serum biochemical indices of nutritional status indicated no deficiencies for any nutrients. The MRE grp obtained 100% of their MRDA for protein and demonstrated a positive nitrogen balance. There were no differences in road march times between groups or over time. Questionnaire assessment of moods and health symptoms indicated that subsisting on MREs did not impair perceived health, cognitive behavior, or affective behavior. The results indicate that, although caloric intake is low, performance and overall nutritional status are not impaired when soldiers consume only MRE XIIs for 30 days.

14. SUBJECT TERMS
rations; Meals, Ready-to-Eat; MRE; nutrition; dietetics; weight loss; body composition; hydration; energy intake; nutrient intake; moods; foot march; food acceptance; flameless ration heater; biochemistry

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LIST OF SYMBOLS, ABBREVIATIONS, AND ACRONYMS

ALT - alanine aminotransferase
ANOVA - analysis of variance
AST - aspartate aminotransferase
ARTEP - Army Training and Evaluation Program
BUN - blood urea nitrogen
CAN - Computerized Analysis of Nutrients System
CFFS - Combat Field Feeding System
CMNR - Committee on Military Nutrition Research
DEXA - dual energy X-ray absorptiometry
FRH - flameless ration heater
FTX - field training exercise
GGT - gamma glutamyl transferase
GI - gastrointestinal
HDL cholesterol - high density lipoprotein
LAIR - Letterman Army Institute of Research
LDH - lactate dehydrogenase
LDL cholesterol - low density lipoprotein
MANOVA - multiple analysis of variance
MRDA - Military Recommended Daily Allowance
MRE - meal, ready-to-eat, individual
MCI - meal, combat, individual; replaced the Ration, Combat, Individual (C Ration)
NRDEC - Natick Research, Development and Engineering Center
OTSG - Office of the Surgeon General
RLW - ration, lightweight
TECOM - U.S. Army Test & Evaluation Command
USARIEM - U.S. Army Research Institute of Environmental Medicine

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Never before have we encountered a more cooperative group of volunteers; the slogan used by soldiers in this unit "we like to think that we can make anything happen" was demonstrated in their care to understand and meet the conditions required by the study design. We are grateful to the men who so generously participated. We especially acknowledge the contributions of the Commander, CPT Tey Wiseman; Executive Officer, 1LT William Young; and First Sergeant William Hammond, who ensured the success of this study. We are also grateful to the senior Engineer officers who invited us to perform nutrition studies with engineering units at Fort Leonard Wood, Missouri.

Finally, we thank COL David Schnakenberg, the Director of the Army Systems Hazards Research Program at the time of this study, for his guidance and support in the accomplishment of this project.

This study was supported in part through a cooperative agreement with the Pennington Biomedical Research Center, Louisiana State University, Baton Rouge, Louisiana, and by funding from the Ration Sustainment Testing Program.

EXECUTIVE SUMMARY

Field expediency occasionally requires military personnel to subsist on operational rations such as the packaged ration, Meal, Ready-To-Eat, for extended periods of time. This study assessed soldiers' ability to meet nutritional needs and to maintain performance while solely consuming the MRE XII in a field environment for 30 days. The study was conducted at Ft. Chaffee, Arkansas, with soldiers from the 902d Engineer Company. Thirty-five soldiers received only MREs (MRE group) and were compared to 32 soldiers who received two A Ration meals and one MRE daily for 30 days (control group). Body weight and food consumption were recorded daily. Body composition measures by dual energy x-ray absorptiometry, blood and urine sample collections, physical performance tests, and mood and symptom surveys were conducted at the beginning, midpoint, and end of the study. Energy consumption was significantly less in the MRE group (2445 ± 151kcal/day) than the control group (2900 ± 239 kcal/day), and greater weight loss occurred in the MRE group (6.8 ±4.5 lbs; 3.8% of initial weight) than in the control group (3.2 ±5.0 lbs; 1.9% of initial weight). The greatest weight loss occurred in soldiers from the MRE group who intentionally tried to lose weight. The MRE dieters lost 3.4% of initial body weight (3-4 lbs/week) during the first two weeks of the study and continued to lose at a rate of 1-2 lbs/week. The non-dieting MRE and control group soldiers never lost at a rate greater than 2 lbs/week. The non-dieting MRE group and control group soldiers lost 3.1 and 1.2% of initial body weight, respectively, by day 30 of the study. Weight loss in this study could not be attributed to dehydration and was almost exclusively due to a reduction in body fat stores. Soldiers in the MRE group consumed only 55% of the energy provided, producing an average energy deficit of 600 kcal/day below the actual requirement of 3000-3200 kcal/day. The MRE group ate less than the Military Recommended Dietary Allowances (MRDA) for calcium, vitamin B_{12}, zinc, iron, magnesium, and folacin. The control group's consumption was below the MRDA for only magnesium and folacin. Laboratory indices of nutritional status indicated no deficiencies for any nutrients within the timeframe of this study. Even with incomplete consumption of the MREs provided, the soldiers in the MRE group obtained 100% of their MRDA for protein and demonstrated a positive nitrogen balance. There were no differences in road march times between groups or over time. Questionnaire assessment of moods (alertness, relaxation, confusion, sleepiness, etc.) and health symptoms (constipation, diarrhea, hunger, thirst, etc.) indicated that subsisting on MREs did not impair perceived health, cognitive behavior, or affective behavior. The results indicate that, although caloric intake is low, performance and overall nutritional status are not impaired when soldiers consume only MRE XIIs for 30 days.


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INTRODUCTION

Operational rations are intended to sustain soldiers for extended periods of time. Although nutritious operational rations have existed since World War II, there are relatively little data on which to base a determination that soldiers are adequately supported with continued use of any of these rations. The assumption that because a ration is nutritionally adequate it will sustain the soldier indefinitely is tenuous (Johnson & Sauberlich, 1982). First, a soldier must be willing to eat an adequate amount of the ration even under adverse conditions. Secondly, the intake must support metabolic requirements during stressful and demanding field conditions. Finally, the ration should be optimized to support not merely basic metabolism but actual physical and psychological performance of the soldier in combat. The adequacy of operational rations can only be confirmed by tests involving soldier consumption under realistic field conditions.

The Meal, Ready-to-Eat (MRE) ration replaced the Meal, Combat, Individual (the C Ration) in 1984 as the primary operational ration for the U.S. Army. It was developed by the U.S. Army Natick Research, Development & Engineering Center (NRDEC) during the 1970's. It was one of the first rations adopted to meet the subsistence concept of supplying nutritionally balanced meals. A ration is the food allowance for one person for one day as prescribed by military regulations; a meal is a nutritionally balanced food unit consisting of approximately one-third of the prescribed daily requirement of a ration. The conceptual change between the C ration and the MRE is that the meals were engineered to allow interchange with other operational meals while insuring nutritional adequacy. This allows maximum flexibility to provide subsistence to soldiers operating away from fixed feeding facilities (Operational Rations, 1990). The MRE also improved on the C Ration by a reduction in weight and an increased variety of components. Weight per meal decreased from 1.8 to 1.0 pounds and included a slight decrease in volume. A key objective in the MRE development program was to produce food components that were ready-to-eat and highly acceptable to soldiers, even under conditions precluding meal preparation (Operational Rations, 1990).

Numerous field studies have evaluated specific aspects and uses of the MRE since its development (Table 1). The MRE was first field tested by NRDEC during a 34-day field training exercise at Pohakuloa Training Area in Hawaii in 1983 (Hirsch et al., 1984). The results indicated that this original version of the MRE produced an unacceptably high weight loss, explained, at least in part, by a low voluntary

Table 1 Field studies involving the MRE

Year tested	MRE version	Duration of test	Study reference
1983	original	34	Hirsch et al. 1984
1984	original	12	Askew et al. 1986 (altitude)
1985	IV(+T)	42	CFFS, 1986; Teves et al. 1986
1986	III	10	Roberts et al. 1987; Engell et al. 1987 (cold)
1987	IV,VII,VIII	12	Popper et al. 1987
1987	VI	30	Askew et al. 1987 - RLW study
1988	VIII	11	Morgan et al. 1988 (cold)
1989	VI, VIII	10	Edwards et al. 1989, 1990 (cold)
1991	X	10	Moore et al. 1992 (restricted to 1 meal/d)

+T = at least one of 3 meals per day included the tray ration

consumption of the ration. Soldiers eating only the MRE lost 10 pounds (5.8% of body weight) as compared to 4.7 pounds (2.6% of body weight) for soldiers eating two A-ration meals and one MRE daily. Although much of the weight loss occurred early in the experiment, the soldiers who were fed three MREs continued to lose weight at the rate of 1% per 12 days throughout the study, whereas body weight of soldiers eating the mixed rations stabilized. The greater weight loss experienced by soldiers eating only MREs appeared to be a result of a lower daily energy intake (2200 kcal) compared to soldiers eating the A-MRE-A ration cycle (3000 kcal). There were no adverse effects on cognitive or psychomotor performance by either ration type. The results of this study suggested low nutrient intakes and poor consumer acceptance of the original MRE.

The MRE IV was field-tested in 1985 in conjunction with the Combat Field Feeding System (CFFS) test by the Nutrition Research Task Force of the U.S. Army Research Institute of Environmental Medicine (Teves et al. 1986). Soldiers of a combat service support unit were fed combinations of the MRE IV and hot meals (either T-ration, B-ration or A-ration) for 42 consecutive days of a field training

exercise. Although there was a modest weight loss, this tended to recover over time and by the end of the 42 days, the average weight loss for male soldiers was 1.5% of body weight, with no significant differences between ration groups. Nearly 10% of the soldiers eating two MREs daily lost 7.5% of their body weight; however, weight loss in all ration groups was related to initial level of adiposity. The fattest quartile of male soldiers, greater than 23% body fat, lost the most weight by day 20: 3.1 kg. The leanest quartile, less than 16% body fat, lost only 0.3 kg by day 20. Nearly all of this weight loss was excess fat weight. Female soldiers fed two MREs and the Tray ration lost an average of 2.5% body weight but gained lean mass. There were no significant reductions or differences between groups in a battery of strength and endurance tests. These results suggested that the MRE could sustain soldiers for 30 days in the field, although no group subsisted exclusively on MREs in this test.

The two Hawaii MRE studies led to a policy decision by the Office of the Surgeon General to restrict the use of the MRE as the exclusive source of subsistence to no more than 10 consecutive days. This was based on the finding of a 3% body weight loss by 10-12 days and a decision that this magnitude of weight loss should not be exceeded. The decision reflected the concept that weight loss indicated an inadequate ration. As a result, 3% weight loss and the 10-day limit became boundary conditions for all ration use and ration development.

The Hawaii MRE studies also resulted in the start of an MRE improvement program (Operational Rations, 1990). A number of changes were made to the MRE in order to improve soldier acceptance of the ration and to increase voluntary intakes. The changes included developing new entree items and replacing old entrees, increasing the entree size from 5 ounces to 8 ounces for most entrees, adding fruit flavored beverage powders to all menus, providing tabasco sauce with each meal, replacing some dehydrated fruits with wet pack fruits, and adding commercial candies to all menus.

A 12-day field-feeding test to measure energy intake and weight loss by soldiers eating improved versions of the MRE was conducted in Hawaii in 1987 (Popper et al., 1987). Soldiers eating the MRE VIII consumed 2800 kcal daily and lost 2.3% of body weight during the study, while soldiers who ate MRE IV or MRE VII consumed 2500 kcal daily and lost 3% of body weight. This suggested that the newer version of the MRE was better accepted and reduced the rate of weight loss.

Although it is desirable to have operational rations capable of maintaining body weight of soldiers in the field, the failure of a ration to prevent body weight losses may not be sufficient reason to limit its consumption in the absence of significant nutritional, physiological and psychological consequences. Energy intakes as low as 600 kcal/d can produce large body weight losses in a short period of time during field exercises (4-5% of body weight in 10 days)(Consolazio et al. 1979); however, this has not been shown to affect physical performance as long as soldiers receive enough carbohydrate to prevent ketosis (Henschel et al. 1954). At least 1500 kcal/d are needed to prevent the negative nitrogen balance associated with caloric deficit. This is important as weight loss is usually not just from fat stores but includes approximately one third contribution from the lean tissues (Askew et al. 1987; Forbes, 1993). In theory, this loss of lean mass will be accelerated by stress-induced catabolic actions on the muscle. Chronic undernutrition leading to significant losses of skeletal muscle will produce physical performance deficits in work capacity (Spurr, 1986) and muscular strength (Grande, 1986); however, noticeable deficits may not occur for body weight losses of less than 10%, as long as sufficient calories and fluids are consumed to prevent dehydration, ketosis, and hypoglycemia (Taylor et al. 1957; Grande et al. 1986).

More recent research using operational rations under a variety of environmental and tactical conditions have not conclusively demonstrated that the loss of more than 3% body weight represents a genuine threat to soldier safety and mission capability. Askew et al. (1987) conducted a field feeding study in which soldiers consumed only MRE VII (with a supplement pack) or the Ration, Light Weight (RLW) for 30 consecutive days. Soldiers who ate the RLW consumed 2000 kcal/d and lost 6.3% of their body weight, while those who ate the MRE consumed 2800 kcal/d and lost 2.2% of their body weight. Although the magnitude of weight loss was different between the two groups, both groups experienced similar declines in aerobic capacity, declines which could also be attributed simply to aerobic detraining during field exercises. There were no meaningful decrements in physical strength and endurance, mood, or performance on psychomotor tests in either group of soldiers. These results suggest that body weight losses of 3-6% do not necessarily represent a performance threat to soldiers consuming operational rations for periods greater than 10 days.

An operational ration must provide the nutrients, vitamins and minerals required by soldiers consuming it. This cannot be assessed simply by an analysis of the composition of the rations consumed because of differences between intakes, absorption, and individual and situational requirements. Several MRE

studies indicated that intakes of some minerals and vitamins such as calcium, magnesium, iron and folate do not meet the Military Recommended Daily Allowances (MRDA) (Askew et al., 1987; Morgan et al., 1988; Edwards et al., 1989; Askew et al., 1986), although biochemical indicators of nutrient status did not reflect the theoretically inadequate intake of these nutrients (Askew et al., 1987; Lichton et al., 1988). In a study of Ranger students in 1991, Moore et al. (1992) found no deficits in serum vitamins, minerals, or any clinical chemistry parameters following a 10-day period involving intensive mountaineering training and consumption of usually just one MRE per day, with no other supplements. This suggests that, except for large weight losses from the energy deficit produced by inadequate caloric intake, the MRE was nutritionally adequate (in terms of blood nutritional markers) for 10 days of feeding even at one third of the normally intended intake.

A nutritionally adequate ration also should not inadvertently increase the incidence of other problems. Retrospective and anecdotal reports from soldiers consuming the MRE and other field rations consistently suggest that the incidence and severity of gastrointestinal complaints, particularly constipation, are more prevalent when eating operational field rations than when the soldiers are eating a regular diet in garrison. Such problems could be due to the ration, inadequate consumption of fluids, disruption of biological rhythms, psychological stressors and inconveniences associated with field training, or a combination of any of these factors. The incidence of self-reported gastrointestinal distress symptoms and the number of sick-call visits for gastrointestinal complaints were not significantly higher for soldiers eating two MREs daily during the 1985 CFFS Study. The overall rate of occurrence was very low and the number of duty days missed were insignificant (CFFS, 1986). Thus, there is a paucity of objective data to support claims that operational rations contribute to a higher incidence of gastrointestinal complaints although this is an important consideration when new rations are evaluated.

Experimenter-administered tests of cognitive and affective behavior are often insensitive to changes induced by nutritional and exercise stress, because the demand characteristics of the setting induce subjects to marshal their resources and perform to standard (Adair, 1973; Committee on Military Nutrition Research, 1986a). Self-perceptions of cognitive and affective behavior are often more accurate assessments of stress-induced deficits, because they are based on comparisons to a chronic, stable baseline and frequent sampling of behavior (Askew et al., 1987). Changes in moods and symptoms can therefore signal

incipient performance degradation. Moreover, mood shifts per se may create an escalating cycle of lethargy, inattentiveness, and apathy which could induce performance failures in the absence of any substantial deficit in intellectual capacity. For these reasons, the assessment of the impact on moods and symptoms of extended subsistence on field rations is essential to an understanding of the role of rations in maintaining health and performance.

Other than body weight loss, the three studies which fed MREs for at least 30 days did not find any negative effect on physical and mental performance, nutritional status or health that was attributable to consumption of the MRE (Hirsch et al., 1984; CFFS, 1986; Askew et al., 1987). The available information indicates that consumption of the MRE for up to 30 days does not compromise the ability of the soldier to complete his or her mission. However, this has been incompletely tested. The more recent versions of the MRE (version IX and later) which include reductions in fat content have not been tested with respect to weight loss, nutrient intake, nutritional status, and health of soldiers eating these rations during extended field-feeding scenarios.

A panel of eminent nutrition scientists from the National Academy of Sciences (the Committee on Military Nutrition Research), reviewed the data from the 1985 CFFS study and offered several recommendations for future research. They suggested that since the MRE might be considered for use for longer than 10 days, specifications for the MRE should be expanded to include all nutrients with Recommended Dietary Allowances. This required expansion and validation of the nutrient database for all ingredients which would be used in formulating the rations. Subsequent efforts by USARIEM and NRDEC yielded significant progress in this area. The CMNR also recommended that consumption of individual ration items in MRE field tests should be reviewed to determine whether fortified items are consumed in sufficient amounts to ensure the intake of adequate amounts of all nutrients. This was one objective of the present study, which utilized blood biochemical assessments in an attempt to demonstrate adequate intake and absorption of key nutrients.

The present study was performed in response to a request from the Chief of Staff of the Army to the Office of the Surgeon General (10 July 1987) to determine if a policy could be set which would allow feeding of the MRE for more than 10 continuous days. The study was conducted as part of the Ration Sustainment Testing Program, funded by the Office of the Deputy Chief of Staff for Logistics. The original plan was to study the MRE VIII but a further improved version, the MRE XII, was available by the time this study took place.

The objective of this study was to test the MRE XII when consumed as the sole source of subsistence for 30 days by soldiers performing moderate to heavy work during a field training exercise. This was achieved by comparison of soldiers consuming only the MRE XII to soldiers consuming usual field rations which included two hot meals and one MRE XII per day. The following key questions were addressed by this study:

1. Do soldier intakes of the MRE XII meet the Military Recommended Dietary Allowances (MRDA) as stated in AR 40-25?

2. Is this level of intake adequate to maintain nutritional status as indicated by body weight, muscle mass, nitrogen balance, and serum biochemical markers?

3. Does the use of the MRE XII adequately support soldier performance, as reflected in moods, symptoms and road march performance?

4. How is the adequacy of soldier intakes of the MRE XII affected by acceptance of individual MRE XII food components?


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METHODS

The study was approved by the Scientific Review and Human Use Review Committees at the U.S. Army Research Institute of Environmental Medicine, Natick, Massachusetts, and by the Human Use Review Office, U.S. Army Medical Research and Development Command, Fort Detrick, Maryland.

The study was conducted 4 October - 4 November 1991 using volunteers from the 902d Engineer Company (Amphibious Float Bridge), 136th Engineer Brigade, Fort Leonard Wood, Missouri who were participating in a regularly scheduled field training exercise at Fort Chaffee, Arkansas. The study was done in conjunction with a Ribbon Bridge Evaluation conducted by the U.S. Army Test and Evaluation Command (TECOM). During the field exercise, soldiers were engaged in these bridging activities as well as a routine Army Training and Evaluation Program (ARTEP) exercise consistent with mission requirements. All experimental study procedures were coordinated in advance and incorporated into the 902d Engineer Company's Operations Order for deployment to Ft. Chaffee. Appendix B shows the training calendar and data collection schedule.

TEST VOLUNTEERS

Potential participants in this study were briefed about the risks and benefits associated with the study and were instructed that they could withdraw from the study at any time without penalty. Volunteers were then asked to give their written informed consent (Appendix A). Volunteers who reported having recurring back or musculoskeletal injuries or gastrointestinal problems were not selected for participation in the study. Sixty-six volunteer male test subjects participated in this study; 34 soldiers were randomly assigned to the MRE group and the remaining 32 soldiers (including several soldiers who stated at the outset that they would volunteer only for the control group) were placed in the control group.

Demographic characteristics of the participants are summarized by study group in Table 2 (Appendix C - Demographics Questionnaire). Ages were 25.5 ±4.5 and 24.7 ±5.5 years, and time on active duty averaged 5.5 and 4.2 years, for the MRE and control group, respectively. Some demographic differences between the MRE and control group emerged after data analysis, including a larger proportion of smokers and non-Hispanic white soldiers in the MRE group.

Table 2 Demographic characteristics of the study volunteers.

	MRE Group		Control Group	
	n (n=34)	%	n (n=32)	%
Education level				
Some High School	2	5.9	0	0
High School Graduate	30	88.2	25	78.1
College Degree(s)	2	5.8	7	21.9
Race				
Non-Hispanic White	25	73.5	17	53.1
Black	5	14.7	6	18.8
Hispanic	3	8.8	4	12.5
Asian	0	0	1	3.1
Native American	1	2.9	4	12.5
Smoking habits				
Do not smoke/not smoked >1 yr	14	41.2	22	68.8
Quit within past 12 months	2	5.9	2	6.3
Smoke < 1 pack daily	9	26.5	4	12.5
Smoke 1 - 2 packs daily	8	23.5	4	12.5
Smoke > 2 packs daily	1	2.9	0	0
Alcohol use				
Do not drink	9	26.5	7	21.9
Less than 2 drinks/wk	13	38.2	13	40.6
1 - 2 drinks/day	9	26.5	8	25.0
> 2 drinks/day or 14 drinks/week	3	8.8	4	12.5
Weight loss desired (desire to lose > 7 lbs)	11	32.2	8	25.0
Weight gain desired	4	11.8	7	21.9

RATIONS

The MRE group was provided three MREs, three Flameless Ration Heaters, and two MRE pouch bread each day. The MRE XII Menu is listed in Appendix J. The control group was fed a standard field ration menu cycle based on two hot A Ration meals and one MRE daily. The 30-day A ration menu used during this study appears in Appendix K. No supplemental foods or beverages were permitted at any time during the study period except for those that were provided by the testing team. This was enforced by the chain of command, but soldiers were not physically restricted to the operational area for the duration of the test and could have obtained some supplementation on periodic visits to a nearby town. The ration issue for both groups was in accordance with AR 30-21, and provided sufficient quantities of nutrients to meet the MRDA given in AR 40-25 if all components were eaten. Data were collected for 30 days, though some results are reported for shorter periods due to missing data.

DATA COLLECTION

Food and Fluid Intake

Food and water intake were recorded daily. The MRE group eating only MREs used dietary log sheets (Appendix D) to self-record daily food and fluid intake. The control group soldiers used the log sheets to record their consumption of food from the MRE. The day prior to the start of the study, subjects were instructed on how to properly complete the food and fluid intake data cards. Trained data collectors collected the log sheets and reviewed them with each volunteer daily to ensure that the cards were filled out completely. Self-recorded food and fluid intake methods have been shown to produce reliable results (Cameron et al., 1988).

Food intake of the soldiers eating the two hot meals daily was recorded using a visual food estimation technique (Rose et al., 1987). Data collectors were trained at USARIEM prior to departing for the study site and received a review training session at the midpoint of the study. Three data collectors recorded food intakes at every hot meal and each data collector was assigned to collect data from the same soldiers each time. The data collectors recorded the amount of food served to each soldier and the amount of food not eaten by each soldier using a food record card (Appendix E).

Nutrient Intake

Nutrient intakes were calculated from the food item intake data collected from the dietary logs and from the visual estimation records by using USARIEM's Computerized Analysis of Nutrients (CAN) System (Rose et al., 1989). Specific nutrients calculated were energy, protein, carbohydrate, fat, sodium, potassium, iron, magnesium, zinc, calcium, phosphorus, thiamin, riboflavin, niacin, pyridoxine, ascorbic acid, folacin, and vitamin A. Mean nutrient intakes were compared to the MRDAs (AR 40-25, 1985).

Anthropometry and Body Composition

At the beginning of the study, height was measured using a free-standing anthropometer, with the volunteers standing on a flat surface and the head positioned in the Frankfort plane. Body weight (in shorts and t-shirt only) was measured daily throughout the study using a calibrated digital electronic battery powered scale accurate to 0.1 kg (SECA Model 770, Columbia, MD). Weight was measured in the morning prior to the first meal of the day. When subjects worked at night, the weight was measured upon awakening but prior to eating a meal.

Body composition was determined at three points during the study (days 3, 14-15, and 29) by dual-energy x-ray absorptiometry (DEXA) and by tape circumference measurements (AR 600-9, 1986). The data collection efforts at the midpoint period occurred over a 2 day period because of time constraints imposed by the training schedule.

For DEXA measurements, subjects lay face up on a DEXA scanner table (DPX-Plus, LUNAR Corp., Madison, WI) in shorts and t-shirt, and were carefully positioned so that the body was centered, hands placed palms downward, knees kept together with velcro straps, and feet supported so that they leaned away from the body at approximately 45°. Each subject was scanned in 1 cm slices across the body, beginning from the head, at the "fast" 10 minute scanning speed. Approximately 6000 pixels of data were analyzed using the Lunar software version 3.4 algorithms to provide body fat, total lean body mass and bone density measurements. The DEXA instrument was assembled and calibrated at the test site by a representative of the manufacturer.

For circumference measures, triplicate sets were made (to the nearest 0.1 cm) using a Gulick-type fiberglass tape measure at the neck and abdomen at the

navel. Body fat was estimated using the technique described in AR 600-9 (the Army Weight Control Program).

Physical Performance

The impact of the diets on the ability of the soldiers to perform heavy physical work was assessed using a road march evaluation test. This test required each soldier to perform an 8-mile road march carrying a total load of 30% of their original body weight in the best time possible. A baseline assessment was done on the first day of the study and a post-test evaluation was made on day 30. The weight of the load carried was the same for both road marches. The road march course was a combination of asphalt surfaced and dirt or gravel unsurfaced roads and trails in the Fort Chaffee Training Area.

Mood and Symptom Assessment

A neurophysiological questionnaire was used to assess whether extended use of a field ration was associated with changes in self-perceptions of affective behavior, cognitive behavior, or health. Previous studies of field rations have found that soldiers consistently underreported the incidence and severity of moods and symptoms on standardized assessment instruments (Hirsch et al., 1984; CFFS, 1986). Thus, a new questionnaire was developed which had only 40 items, a simple format, a neutral organization, and a positive rating scale. The questionnaire asked soldiers to use a scale from 1 to 5 ("a little" to "extremely") to rate the degree to which they had experienced each mood and symptom over the last 24 hours (Appendix G).

The questionnaire was administered nine times during the course of the experiment. It was administered the day before the FTX in order to familiarize the soldiers with the form. It was administered just prior to each road march and just after each road march in order to determine if extended subsistence on a field ration would interact with strenuous exercise to change affective, cognitive, or health symptoms . It was administered one to two days after each road march to determine if extended subsistence on a field ration would interact with recovery from strenuous exercise to change affective, cognitive, or health symptoms. It was administered at the mid-point of the FTX (day 13) and the day prior to the second road march to provide additional assessments.

Blood Analysis

Blood samples were collected at three points during the study (days -1, 14, and 31) for the biochemical assessment of some parameters of nutritional status. The day prior to each collection of a blood sample, soldiers were instructed to consume no food or fluid (except plain water) after 2100 hours. They also were asked to drink on that evening a full quart of water prior to sleep to ensure euhydration. Three separate 15 ml samples were collected into vacutainers: one 15 ml blood sample was taken to provide serum, and two 15 ml blood samples (EDTA and heparin as anti-coagulants) were taken to provide unclotted whole blood, plasma, and erythrocytes. Following collection, blood samples were kept cool until processing (completed within 4-5 hours). Serum (or plasma) and cells were separated, and the different blood fractions frozen (-20 C) until shipment on dry ice to the analytical laboratory at Pennington Biomedical Research Center.

Stored blood fractions were analyzed for nutrients and indicators of metabolic status, serum lipids, hematological status, clinical liver function tests, and vitamin and mineral status. Most of these tests were performed on a Beckman Synchron CX5 using colorimetric tests according to the manufacturer's recommendations (Beckman Instruments, La Brea, CA). Short-term indicators of metabolic status included glucose, blood urea nitrogen (BUN), creatinine, uric acid, total proteins, albumin, glycerol, nonesterified fatty acids (NEFA), lactate, and β-hydroxybutyrate. Serum lipids were assessed using colorimetric tests on the same system and HDL-cholesterol was measured using a cholesterol oxidase method following precipitation of VLDL- and LDL-cholesterol with dextran sulphate. LDL-cholesterol was calculated using the Friedewald equation. Hematological parameters were measured using a Coulter counter (hematocrit, hemoglobin, and red cell count). Iron and total iron binding capacity (TIBC) were measured in serum using a ferrozine method. Ferritin was measured by radioimmunoassay (BioRad Laboratories, Richmond, CA). Liver function tests included total bilirubin, lactate dehydrogenase (LDH), aspartate aminotransferase (AST), alanine aminotransferase (ALT), and gamma glutamyl transferase (GGT). Serum electrolytes (sodium, potassium, and chloride) were measured with ion selective electrodes. Serum minerals were measured by colorimetric tests (calcium: Arsenazo III method; magnesium: calmagite method; phosphorus: phosphomolybdate method) on the Synchron CX5. Routine chemistries were verified daily with standard quality control procedures and standardization was confirmed by participation in the College of American Pathologists Survey.

Table 3 Biochemical Indicators used to Assess Vitamin and Mineral Status

VITAMIN/MINERAL	BIOCHEMICAL INDICATORS
Vitamin A (retinol)	Serum retinol concentration
Vitamin B_1 (thiamin)	Functional test: in vitro stimulation of erythrocyte transketolase by thiamin pyrophosphate
Vitamin B_2 (riboflavin)	Functional test: in vitro stimulation of erythrocyte glutathione reductase by flavin adenine dinucleotide
Vitamin B_6 (pyridoxal phosphate)	Functional test: in vitro stimulation of erythrocyte aspartate aminotransferase by pyridoxal-5'-phosphate
Vitamin B_{12} (cobalamin)	Serum cobalamin concentration
Folate	Erythrocyte folate
Vitamin C (ascorbic acid)	Plasma ascorbic acid concentration
Vitamin D (25-hydroxy cholecalciferol)	Serum Vitamin-25-hydroxy-D_3 Serum ionized calcium Serum total phosphorus
Magnesium	Serum total magnesium
Iron	Serum total iron Serum total iron binding capacity (TIBC) Serum ferritin

Vitamin status was measured by direct assay or by biochemical indices summarized in Table 3. Retinol was extracted in hexane and measured by HPLC uv detection. Thiamin, riboflavin and Vitamin B_6 were assessed by sensitive in vitro erythrocyte assays, in which the addition of vitamin to the erythrocytes produces a stimulation of specific vitamin-dependent enzymes, with the extent of enzyme stimulation corresponding to the vitamin status. Vitamin B_{12} and folic acid were measured using radiolabelled ligand assays (BioRad); folic acid was measured in the serum and calculated for erythrocytes from measurement of whole blood diluted in ascorbic acid at the time of collection. Ascorbic acid was measured by colorimetric

assay using ascorbate oxidase and o-phenylenediamine; unusually low baseline values were obtained for ascorbic acid in this study due to an unidentified problem in the preservation and/or assay of these samples which yielded undetectable levels. Vitamin 25-hydroxy-D_3 was measured by radioimmunoassay (Incstar Corporation). Other markers of vitamin D status (calcium and phosphorus) were measured as described above. These methods have been reported in more detail in Moore et al. (1992) and Sauberlich (1984).

Urine Analysis

First void urine samples (50 ml) were collected daily for the duration of the study. Urine samples were analyzed for specific gravity and ketones using a semi-automated system (Rapimat II/T, Behring Diagnostics, Inc., Somerville, NJ). Urine specific gravities greater than 1.030 suggest dehydration in a soldier (Francesconi et al., 1987).

On three occasions (days 1-2, days 13-14, and days 28-29), 24-hour urine samples were collected for two successive days for the determination of urine total nitrogen. These analytical values were used to estimate total body nitrogen balance and to provide information related to stress-induced muscle breakdown or metabolism. Total 24-hour urine volume was recorded, and an aliquot was frozen for later analysis by the Biochemical Analysis Laboratory at the Pennington Biomedical Research Center. Nitrogen (N) balance was calculated using the following formula and with nitrogen intake estimated from protein intake:

$$N_{balance} = N\ Intake_{(g)} - (Urine\ N\ excretion_{(g)} + 2_{(sweat\ and\ fecal\ losses)})$$

Ration Acceptability

Hedonic rating scales for indicating food item acceptance were included on the daily dietary log sheets. Food items consumed were rated on a scale which ranges from 1 (dislike extremely) to 9 (like extremely) with a midpoint of 5 (neither like nor dislike).

Final Questionnaire

A final questionnaire (Appendix F) was administered to each soldier at the end of the study in order to collect a personal evaluation of each ration's acceptability,

human factors (e.g. packaging, preparation, handling, etc.), and subjective performance under field conditions. Acceptance was measured using a nine-point hedonic scale as described above.

STATISTICAL ANALYSIS

Test subjects served as their own controls for the purpose of determining the effect of rations on maintaining body weight and performance during the 30-day test-period. Comparisons of measurements by study groups were used to separate the effect of deployment on food intake.

Statistical comparisons were conducted using the statistical analysis software, Statistical Package for the Social Sciences (version 4.1) on VAX 780 and VAX 6510 mainframe computers. Individual item ratings for each soldier for each administration of mood and symptom assessment questionnaires were analyzed using the CROSSTABS and DESCRIPTIVES subroutines. The data were analyzed using repeated measures ANOVA and MANOVA subroutines to compare between-group differences and within-subjects factors. In some cases, means within the test population were compared across time using paired t-tests. A Student-Newman-Keul post-hoc test was used in some instances to make more comprehensive comparisons of time effects. Post hoc comparison of interaction effects in mood and symptom analyses were made using Tukey's test. Unless otherwise indicated, all values shown represent the mean ± standard deviation of measure with $p<0.05$ as the level of statistical significance.


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RESULTS

INTAKES OF ENERGY AND NUTRIENTS

Daily intake was relatively consistent over the entire study period in each group; however, it was significantly higher in the control group at all time points compared to the MRE group (Table 4). The control group consistently consumed about 430-475 more kcal/d than the MRE group ($p \leq 0.05$).

Daily energy intake of the MRE group usually ranged from 2200 to 2575 kcal/d with only two unusual days (Day 18 = 2000 kcal/d and Day 27 = 2800 kcal/d). Daily energy intake was more variable in the control group than in the MRE group. Energy intakes of the control group ranged from about 2600 to 3000 kcal/d for most days. The control group intake peaked at ~3300 kcal/d on several days (Days 3, 7, 12, and 29) and dropped to about 2400 kcal/d on two occasions (Days 8 and 18). Both groups dropped to low intake levels on Day 18. This was a day off for the unit after they completed three days of heavy training at night; most of the soldiers slept much of the time on Day 18 and skipped one or two meals.

The mean daily intake for each group was significantly greater (by about 100 kcal, $p \leq 0.05$) during Week 4 than the first three weeks. The mean daily intake was not significantly different between any other weeks for either group. Activity increased during the last week of the study as the unit worked more hours each day to make up for training time lost during the third week due to inclement weather.

Table 4 Mean (± SD) Daily Energy Intake Each Week

TRAINING WEEK	MRE	Control
week 1	2457 ±59	2900 ±118*
week 2	2419 ±48	2896 ±112*
week 3	2436 ±72	2868 ± 86*
week 4	2530 ±70#	2964 ± 50*#

* = significantly different ($p \leq 0.05$) between group

= significantly different ($p \leq 0.05$) from other weeks within group

The mean energy intakes for both groups are depicted in Table 5. The MRE group consumed only half of the energy provided (2445±30 of 4450 kcal provided) while the control group consumed 76% of energy provided (2900±48 of 3810 kcal). The MRE group met 77% of the MRDA for energy (3200 kcal) while the control group met 91% of the MRDA for energy. Although the mean intake of the control group achieved the lower limit of the MRDA for energy for young men, this intake was insufficient to meet the actual energy requirements of this field exercise since only 6 of 32 soldiers maintained body weight.

The low consumption rates in the MRE group produced lower than intended intakes of specific nutrients (Table 5). In some cases, such as for Vitamin C and B_6, the intake was less than half of what was offered. However, because of high nutrient densities of the MRE, intake of these vitamins still exceeded the MRDA . For most nutrients, intakes of the MRE achieved quantities approaching 100% of the MRDAs even though total energy intake was low. Intakes were notably deficient for carbohydrates, folate, Vitamin B_{12}, and zinc in the MRE group; several other nutrients were somewhat below the MRDA. These represented the only vitamins and minerals which do not have a nutrient density in the MRE which is high enough to achieve MRDA with consumption of less than three complete meals/d. The control group intake was markedly deficient only for Vitamin E and folate, and it was substantially higher than desirable for cholesterol.

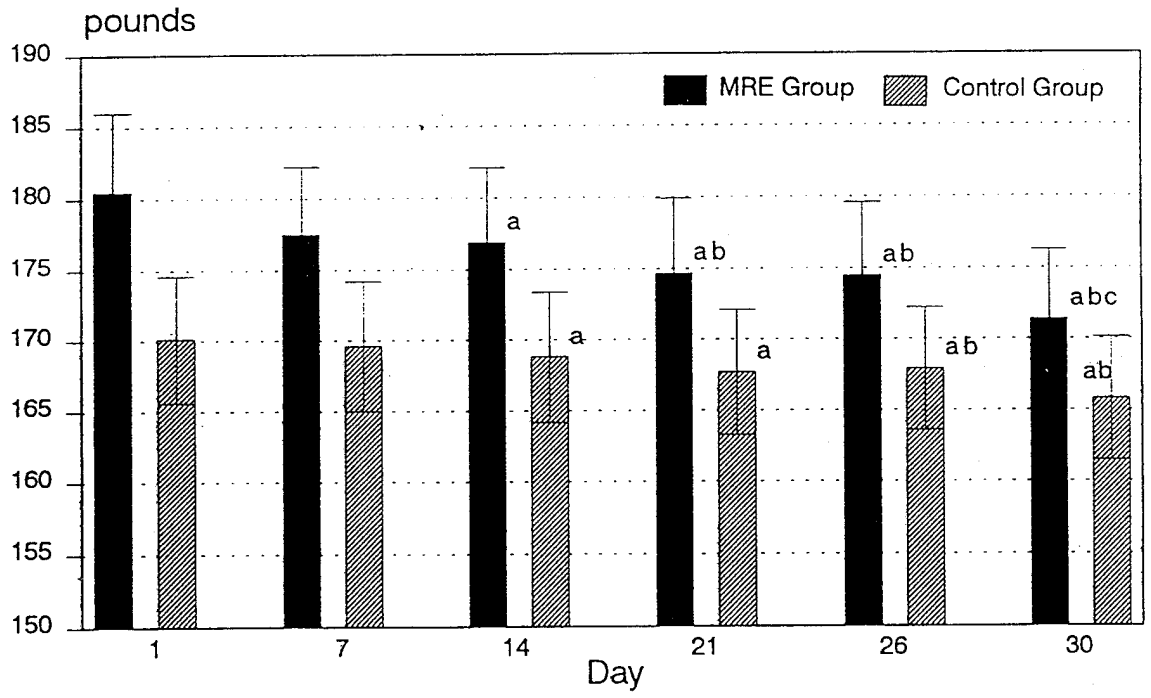
BODY COMPOSITION CHANGES

Figure 1 shows the mean daily weight of each group at weekly points through out the study. The daily weights in the final week are summarized at Day 26 (representing mean weights on days 22-26) and at Day 30 (representing mean weights for day 27-30). Weight data collection was erratic during Days 27-30 due to frequent changes in the training schedule at the end of the study period.

Mean weight of the MRE group declined from 180±31 to 173±28 lbs over the 30 day study. This represented a loss of 6.8±4.5 lbs, or 3.8% of initial weight, at day 30. The control group declined from 169±26 to 166±24 lbs over the same time period, representing a loss of 3.2±5.0 lbs, or 1.9% by day 30.

Post-experimental data analyses of initial questionnaires, revealed that nearly one-third of the subjects were actively trying to lose weight. Twelve MRE group and eight control group subjects indicated that they desired to lose seven or more pounds. This was an appropriate objective for these individuals; the men in the

MRE group who wanted to lose weight averaged 23% body fat (by the circumferential method of body fat assessment in AR 600-9) compared to the other men who averaged 16% body fat. The upper limit for body fat in male soldiers aged 21-27 is 22%. Similarly, men in the control group who wanted to lose weight averaged 22% body fat, compared to an average of 15% body fat for those who did not. Body fat estimated by DEXA was even higher (the Army equation tends to overestimate body fat in individuals with high fat content). On the basis of this information, it became crucial in this analysis to consider weight and body composition changes separately for "dieters" and "non-dieters."



Similar letters are not significantly different

Figure 1 Mean daily body weights summarized by week of study.

Table 5 Nutrients consumed[1] during the Fort Chaffee study, compared as a percent of nutrients provided in the daily ration (% prov) and as a percent of the MRDA (% MRDA).

NUTRIENT	MRDA	MRE Group				Control Group			
		Provided[2]	Consumed	% prov	% MRDA	Provided[3]	Consumed	% prov	% MRDA
Energy (kcal)	2800-3600	4448	**2462±156**	55	77	3807	**2911±237**	77	91
Protein (g)	100	158	**103±6**	64	103	142	**126±13**	88	126
Carbohydrate (g)	350-495	560	**281±20**	50	66	506	**359±36**	71	85
Fat (g)	109-140	175	**103±7**	59	82	140	**110±13**	78	88
Cholesterol (mg)	<300	361	**265±26**	73	88	716	**659±123**	92	220
Vitamin A (IU)	5000	10,851	**5794±599**	53	116	11,638	**7189±1167**	61	144
Vitamin E (mg)	10	19.1	**11.0±0.7**	57	110	5.8	**4.5±0.7**	77	45
Vitamin C (mg)	60	306	**119±15**	39	198	281	**146±27**	52	243
Thiamin (mg)	1.6	8.4	**4.5±0.4**	53	279	4.6	**3.3±0.4**	71	205
Riboflavin (mg)	1.9	3.3	**1.9±0.12**	57	100	3.3	**3.4±0.25**	104	179
Niacin (mg)	21 (NE)	41	**24.5±2**	60	117	35	**27.0±5**	78	129
Vitamin B_6 (mg)	2.0-2.2	5.8	**2.81± 0.3**	48	134	3.6	**2.73±0.3**	75	130
Folacin (µg)	400	237	**163±14**	69	41	384	**304±36**	79	76

NUTRIENT	MRDA	MRE Group				Control Group			
		Provided[2]	Consumed	% prov	% MRDA	Provided[3]	Consumed	% prov	% MRDA
Vitamin B_{12} (µg)	3.0	2.64	**1.63± 0.13**	62	54	5.58	**6.55±1**	117	217
Calcium (mg)	800-1200	1565	**868±64**	55	87	1639	**1520±141**	92	152
Phosphorus (mg)	800-1200	2492	**1463±95**	58	146	2446	**2088±172**	85	209
Magnesium (mg)	300-400	443	**306±34**	69	87	450	**372±31**	83	106
Sodium (mg)	1400-1700	6151	**4314±327**	70	103	6599	**4953±602**	75	100
Potassium (mg)	1600-2000	4248	**2275±174**	54	126	4830	**3592±333**	74	200
Iron (mg)	10-18	19	**12.3±0.9**	64	88	24	**19.5±1.7**	83	140
Zinc (mg)	15	11.2	**9.3±1**	83	62	14.7	**15.3±2**	104	102

[1] Mean ± SD; [2] Mean nutrient amount provided from 3 MRE XII + 2 pouch bread/d; soldiers received random selection of MREs each day and were issued 3 flameless ration heaters (FRH)/d. [3] Mean nutrient amount provided from 2 A Ration + 1 MRE XII/day; control group soldiers did not receive pouch bread. Note: Shaded blocks indicate intakes which were notably low (or high) compared to the MRDA.

Figure 2 shows the mean weights of dieters and non-dieters at the end of each week of the study. Because of the high variance, mean body weights were not significantly different between dieters and non-dieters; however, the rates of weight loss were markedly different between these groups, within experimental groups. The daily self-reported body weight measurements demonstrated slightly higher rates of change than the observer-collected body weights which were recorded during the body composition assessments at the start, midpoint, and end of the exercise. The results reported here (except for the graphical data) represent the observer-collected data.

Dieters in the MRE group lost 5.0±2.3 lbs in the first 2 weeks and an additional 4.7±3.6 lbs by the end of the study. This was substantially higher than the weight loss of non-dieters in the MRE group. The changes in the control group followed the same pattern but represented smaller losses in both the dieters and non-dieters.

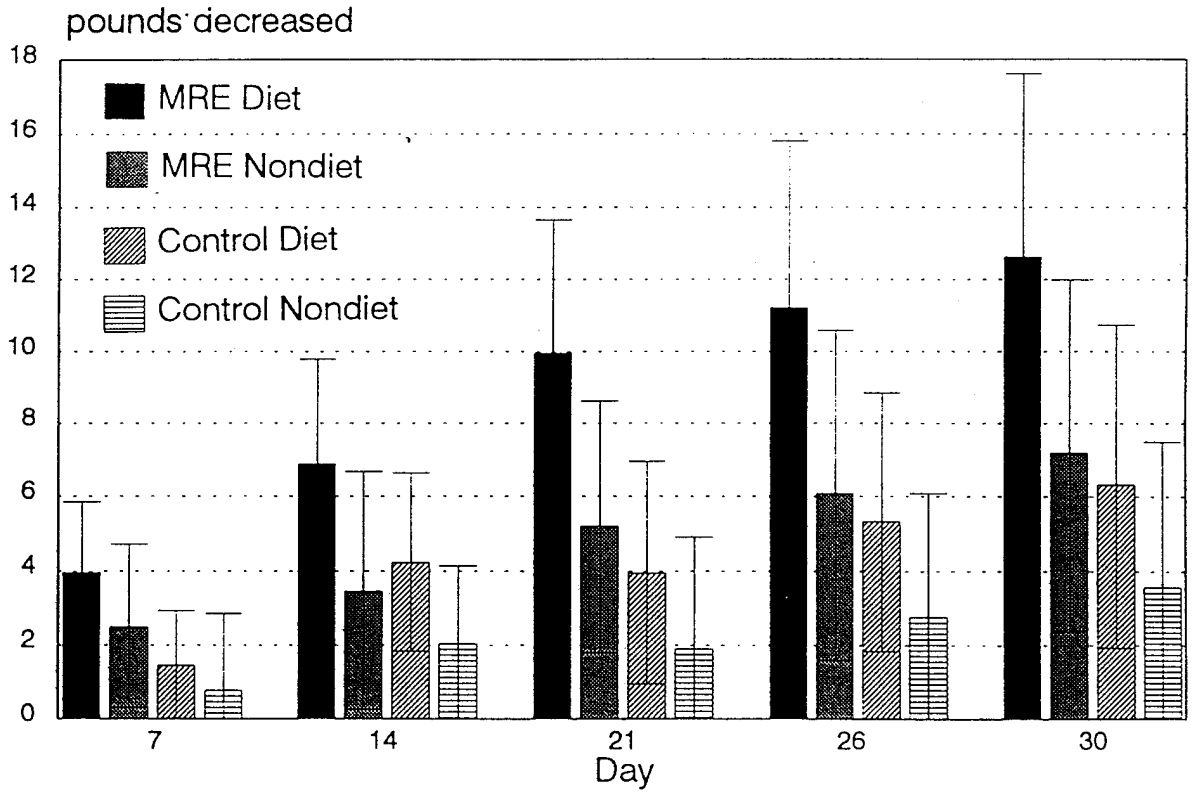


Figure 2 Cumulative weight loss at the end of each week of study.

Comparing only the non-dieters in the two groups, there was a statistically significant difference in the initial rates of weight loss. In the first 15 days, weight decreased by 1.9±2.2 (n=22) and 0.2±1.8 (n=24) lbs for the MRE and control groups, respectively (t-test; $p<0.01$). In the final 15 days, the rate of weight loss accelerated, with decreases of 3.2±2.2 and 1.7±3.2 lbs for the MRE and control groups; however, these changes during Day 15-30 were not statistically different between the MRE and control group. Weight loss in non-dieters over the 30-day study period averaged 3.1% and 1.2% of initial body weights in MRE and control groups, respectively.

Body fat changes reflected the same differences between dieters and non-dieters seen with weight change. Subjects lost 1.9±1.1 and 1.4±1.5% body fat (by DEXA), for the MRE and control groups, respectively. This was a modest loss representing 3-5 lbs of fat. It was a true loss, representing a change 3-4 times above the limits of detection of the DEXA (±0.5% body fat). The soldiers trying to lose weight lost 1.5-2.0% body fat in the two test groups and did not differ significantly in the rate of change from the non-dieters. There were larger decreases in fat-free mass (FFM) in the MRE group dieters compared to non-dieters. FFM increased by 1-2 lbs in non-dieters in both groups during the first two weeks but did not change in the dieters. In the second half of the field exercise, FFM declined in all groups by 0.5-3 lbs. The body fat loss was reflected in the Army circumferential method of fat estimation but the change was only detectable at the end of the course with no significant differences at the midpoint compared to baseline measurements (Figure 3).

On the basis of the change in fat and fat-free weight in the non-dieters, it can be estimated that there was a net energy deficit over 30 days of 600 kcal/d for the MRE group and 340 kcal/d for the control group. These estimates are primarily based on the loss of 3.9 and 2.4 lbs of fat in the MRE and control non-dieters, respectively. Combined with the data on mean intakes (dieters and non-dieters), this indicates energy requirements of at least 3000-3250 kcal/d during this field exercise. The higher value is probably more accurate because the mean intake of the MRE group (2460 kcal/d) is depressed by the 12 dieters who were particularly successful at diet restriction (as evidenced by the highest rate of weight loss).

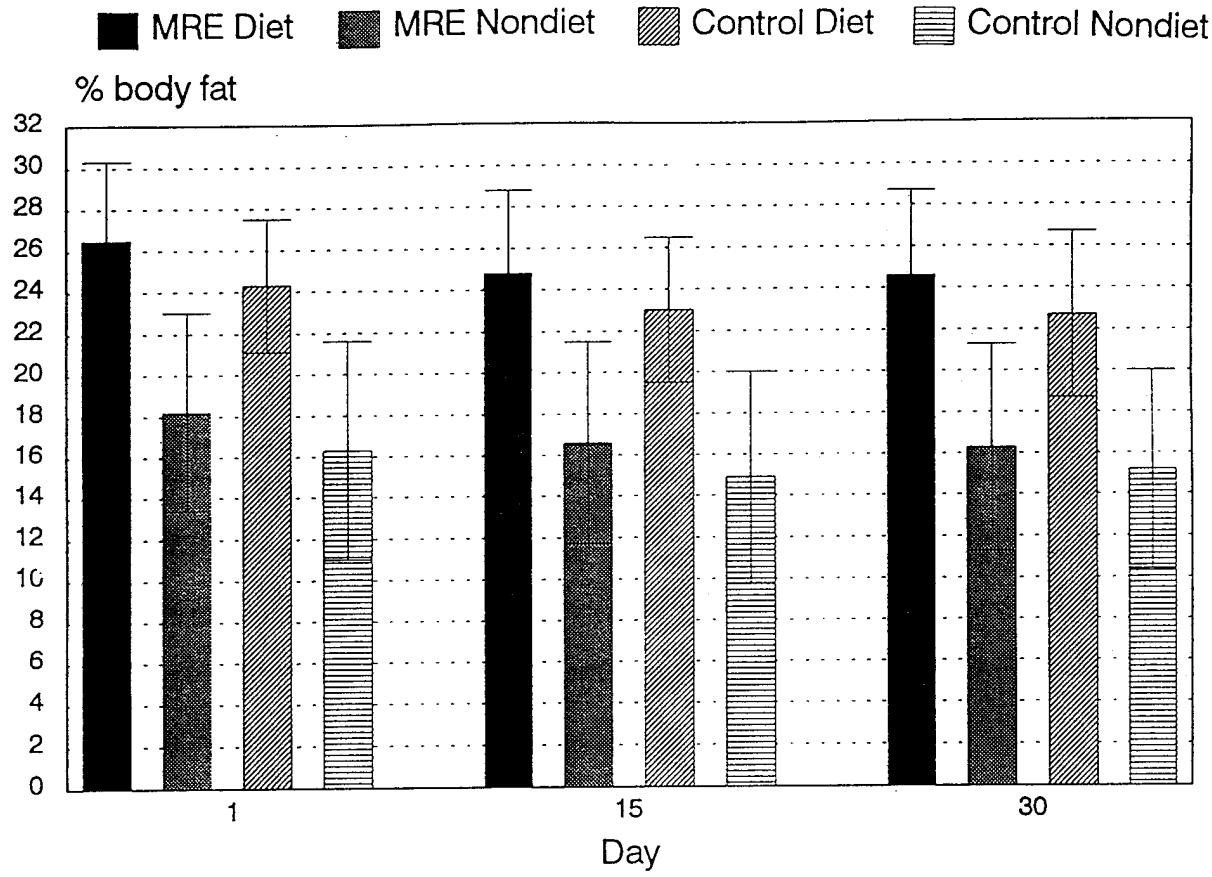


Figure 3 Body fat measured by DEXA at start, midpoint, and end of the study

PHYSICAL PERFORMANCE

Figure 4 shows the results of the road marches conducted at the beginning and at the end of the study. In the initial road march, the mean road march time was 129.6 ±11.5 minutes (fastest - 113.0 minutes, slowest - 144.4 minutes) for the MRE group and 128.2 ±9.2 minutes (fastest - 109.2 minutes, slowest - 149.4 minutes) for the control group. The mean road march times in the final road march were 122.8 ±8.6 minutes (fastest - 99.4 minutes, slowest - 134.3 minutes) for the MRE group and 122.4 ±13.1 minutes (fastest - 86.0 minutes, slowest - 137.1 minutes) for the control group. There was no significant difference between initial and final times within groups or between groups. The slight improvement in the second road march finish times may have been due to colder temperatures (56°F on the day of the initial road march, versus 36°F on the day of the final road march).

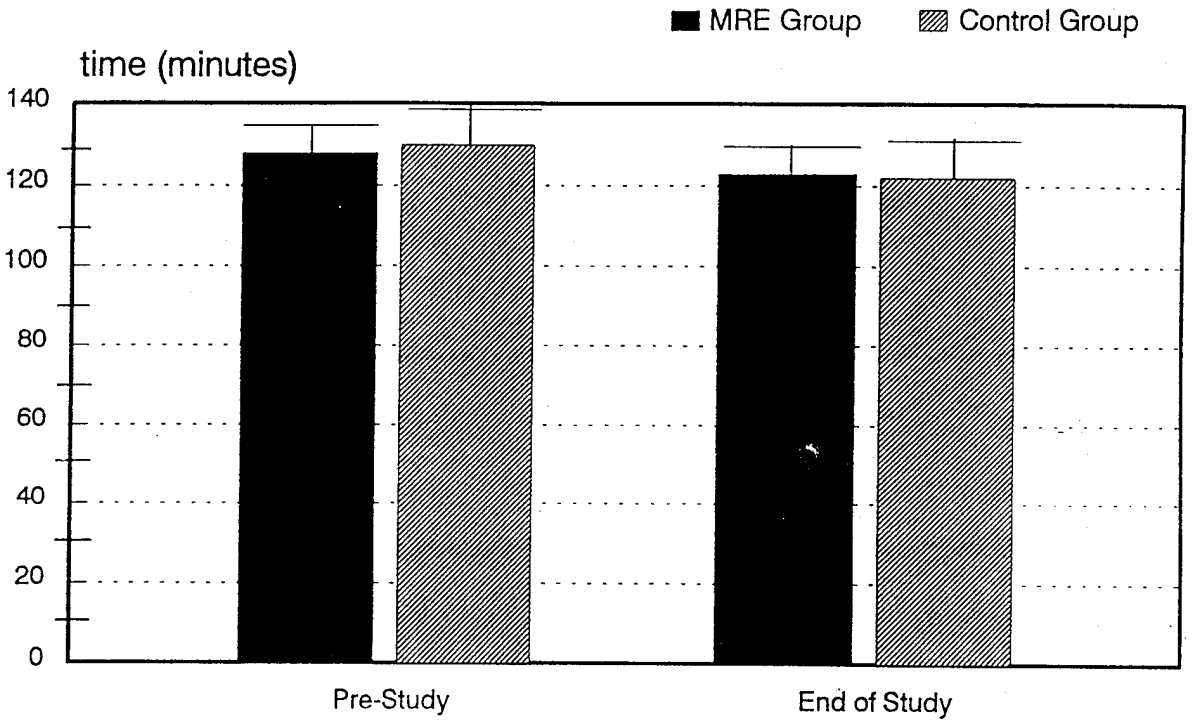


Figure 4 Road march performance

MOOD AND SYMPTOM ASSESSMENT

Ratings on the eight items which assessed gastrointestinal (GI) discomfort or illness were summed to yield a GI symptom score (Table 6). The remaining 32 items were divided into two groups of 16. Ratings on the 16 items which assessed positive moods were summed and divided by the sum of the ratings on the 16 items which assessed negative moods. This yielded a mood ratio score (Table 6). Descriptive statistics on individual items indicated that soldiers used the full range of the rating scale on most items across all administrations, eliminating the extreme skew seen in previous investigations.

Table 6 Items comprising Gastrointestinal Symptom and Mood Subscales

Gastrointestinal Symptom Subscale cold, constipated, diarrhea, hot, hungry, stomach upset, stomach gas, thirsty
Mood Subscale - Positive Items alert, attentive, challenged, cheerful, competent, coordinated, encouraged, energetic, excited, happy, interested, optimistic, powerful, relaxed, rested, strong
Mood Subscale - Negative Items achy, afraid, bored, confused, depressed, dizzy, forgetful, headache, irritated, nervous, overworked, restless, shaky, sleepy, stiff, tired

Effects of 30 days of MREs

A 2 x 3 (Groups by Days) analysis of variance was performed to compare the MRE group to the control group on three successive administrations of the questionnaire. An analysis of moods and symptoms at Day -1, Day 13, and Day 30 was used to determine whether there were any changes in moods and symptoms over the course of the FTX and whether soldiers using the MRE ration were disproportionately affected.

GI Symptom Score. The average GI symptom scores indicated that severe GI symptoms were rare. As shown in Figure 5, there were no significant differences between the groups over the course of the FTX ($p>0.10$) or between the different administrations of the questionnaire ($p>0.20$).

Mood Ratio Score. The average mood ratio scores indicated that, in general, positive moods were rated slightly higher than negative moods. Groups were not significantly different ($p>0.15$), but Days were ($F(2,122)=4.77$, $p=0.01$). However, as can be seen from Figure 6, the difference across days was due entirely to the MRE group (interaction test $F(2,122)=2.98$, $p=0.06$). Their mood ratio score was higher at the midpoint of the FTX, while the control group showed little change over the course of the FTX. These data make it clear that subsistence on MREs did not impair perceived health, cognitive behavior, or affective behavior.

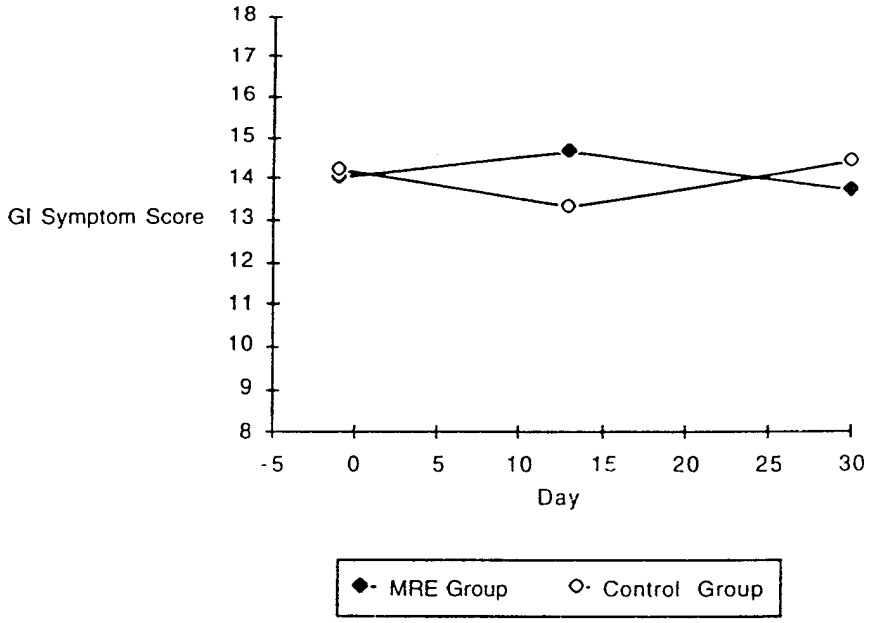


Figure 5. Average gastrointestinal (GI) symptom scores on Days -1, 13, and 30 of the field training exercise.

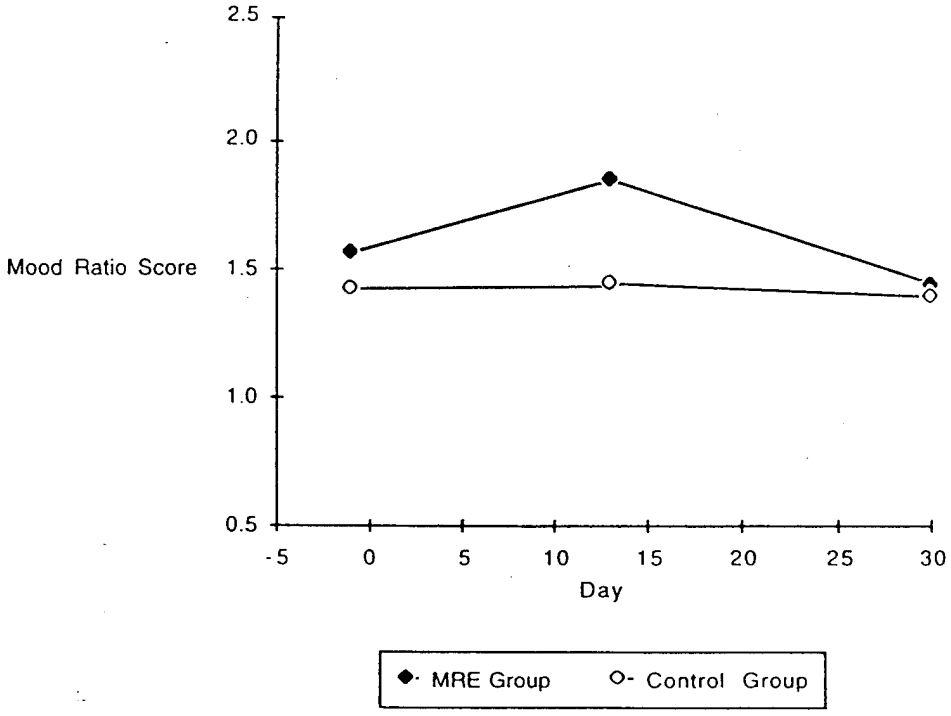


Figure 6. Average mood ratio (positive:negative) scores on Days -1, 13, and 30 of the field training exercise.

Effects of the Road March

A 2 x 2 x 2 (Groups by Days by Marches) analysis of variance was performed to compare the MRE group to the control group before and after the first (day 1) and second (day 29) road marches. This analysis was used to determine whether there were any changes in moods and symptoms after strenuous exercise and whether soldiers using the MRE ration for 28 days were disproportionately affected.

GI Symptom Score. As shown in Figure 7, GI symptoms significantly increased following road marches (main effect $F(1,52)=50.74$, $p<0.001$). However, there was no difference in the degree of increase between the two groups (neither the Groups main effect nor any of its interactions were statistically significant, $p>0.25$). The Days main effect was also statistically significant ($F(1,52)=6.13$, $p<0.02$), but the interaction between Days and Marches was not significant ($p=0.09$), indicating that ratings of gastrointestinal illness were more severe for the first road march than the second. Soldiers were not significantly debilitated by the 28 days of field training and were able to benefit from previous experience in managing gastrointestinal symptoms. Moreover, soldiers subsisting solely on MREs were not different from those subsisting on the Army's standard fare.

Mood Ratio Score. Although both the Days and the Marches main effects were significant ($p<0.003$), there was a significant interaction between Days and Marches ($F(1,52)=6.74$, $p=0.01$). Subsequent individual comparisons using Tukey's test indicated that the ratio of positive to negative moods decreased significantly following the first road march ($q(2,52)=7.01$, $p<0.01$), but not the second road march ($p>0.05$; see Figure 8). Groups were not significantly different in this analysis (neither the Groups main effect nor any of its interactions were statistically significant, $p>0.20$). These data indicate that soldiers responded to the first episode of strenuous exercise in a predictable fashion, adapted well to field training, and were able to sustain health and positive moods whether they were subsisting on MREs or standard rations. These data suggest that there was little or no change in mood from the post-test on Day 1 to the pre-test on Day 29.

Recovery from the Road March

Given the pattern of results shown before and after road marches, it was necessary to make a more detailed analysis of recovery in the days following the road marches. A 2 x 2 x 2 (Groups by March-Days by Recovery-Days) analysis of

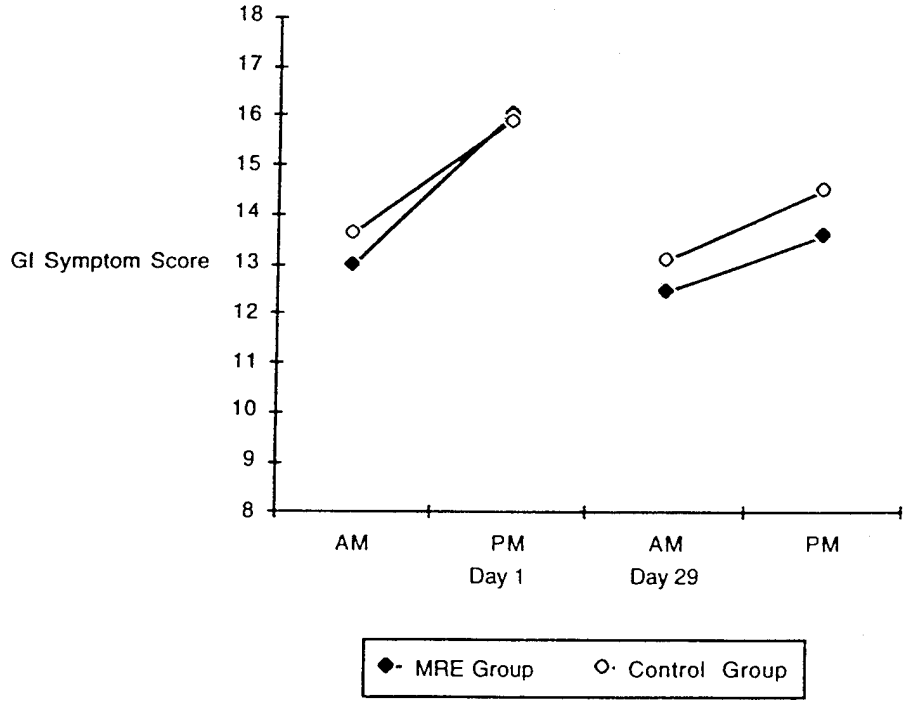


Figure 7. Average gastrointestinal (GI) symptom scores before (AM) and after (PM) road marches.

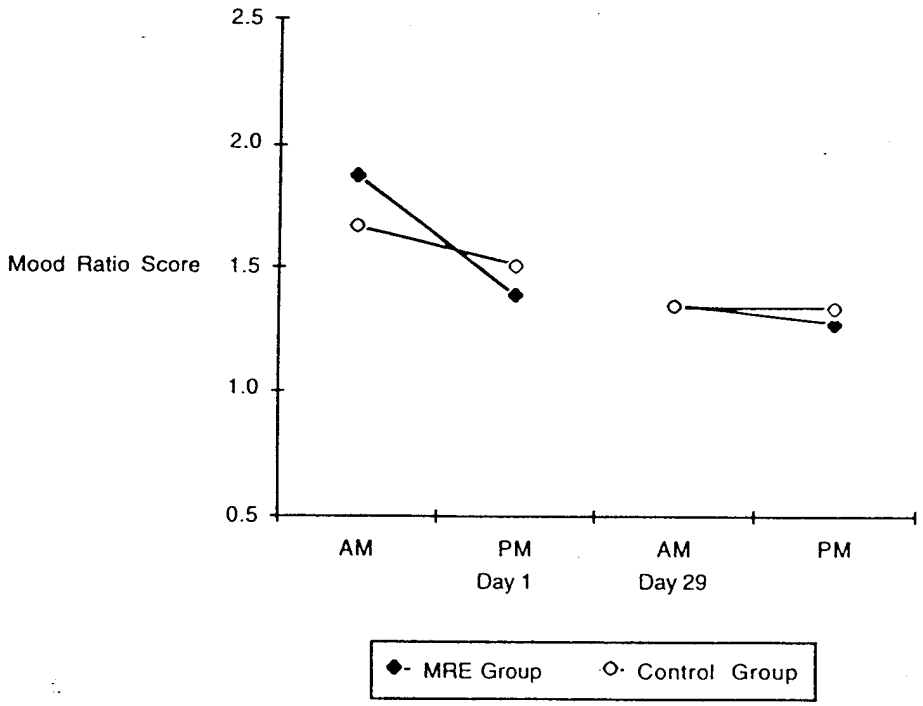


Figure 8. Average mood ratio (positive:negative) scores before (AM) and after (PM) road marches.

variance was performed to compare the MRE group to the control group immediately following the road march (posttest on Day 1 and Day 29) and the day after the road march (Day 3 and Day 30). This analysis was used to determine whether there was any recovery in moods and symptoms after strenuous exercise and whether soldiers using the MRE ration for more than 28 days were disproportionately affected.

GI Symptom Score. As previously discussed (Figure 7), there was a significant increase in the severity of GI symptoms following each road march. Figure 9 illustrates that two days after the first road march (Day 3) symptoms had returned to baseline levels. However, symptoms were still at post-test levels one day after the second road march (Day 30). Groups did not differ in this respect (neither the Groups main effect nor any of its interactions were significant, $p>0.10$). The March-Days main effect was not significant ($p>0.05$). There was a significant Recovery-Days main effect ($p=0.001$), but there was also a significant March-Days by Recovery-Days interaction effect ($F(1,53)=10.42$, $p=0.002$). As expected from the data shown in Figure 9, subsequent individual Tukey comparisons revealed that the decrease from Day 1 to Day 3 was statistically significant ($q(2,53)=5.58$, $p<0.01$), while the decrease from Day 29 to Day 30 was not ($p>0.05$). It may be that 48 hours is required for recovery from GI symptoms or it may be that the second road march was more demanding. In any case, those soldiers subsisting on MREs recovered at least as well as those subsisting on standard Army fare.

Mood Ratio Score. As previously discussed (Figure 8) there was a significant decrease in the ratio of positive to negative moods on the post-test following the first road march, but not the second. As shown in Figure 10, two days after the first road march (Day 3), ratings of moods had returned to baseline levels. Similarly, one day after the second road march (Day 30) , moods again showed recovery, although not to baseline levels. Groups did not differ in this respect (neither the Groups main effect nor any of its interactions were significant, $p>0.15$). As expected from the data shown in Figure 10, the March-Days main effect was significant ($F(1,53)=9.02$, $p=0.004$) as was the Recovery-Days main effect ($F(1,53)= 13.55$, $p=0.001$), but the March-Days by Recovery-Days interaction effect was not ($p>0.10$). Clearly, there was recovery in the days following the post-test for each march and recovery was greater in the two days following the first road march than it was in the day following the second road march. The mood data suggest that soldiers anticipated the rigors of the road march and that 48 hours are required for general recovery. Again, these soldiers subsisting on MREs recovered as well as those subsisting on standard Army fare.

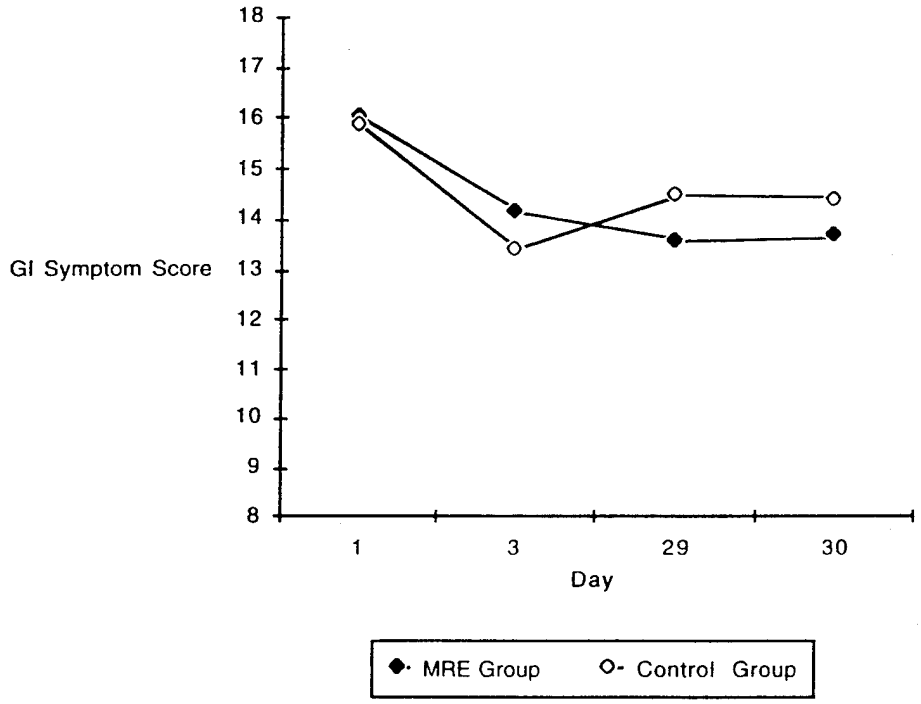


Figure 9. Average gastrointestinal (GI) symptom scores following road marches.

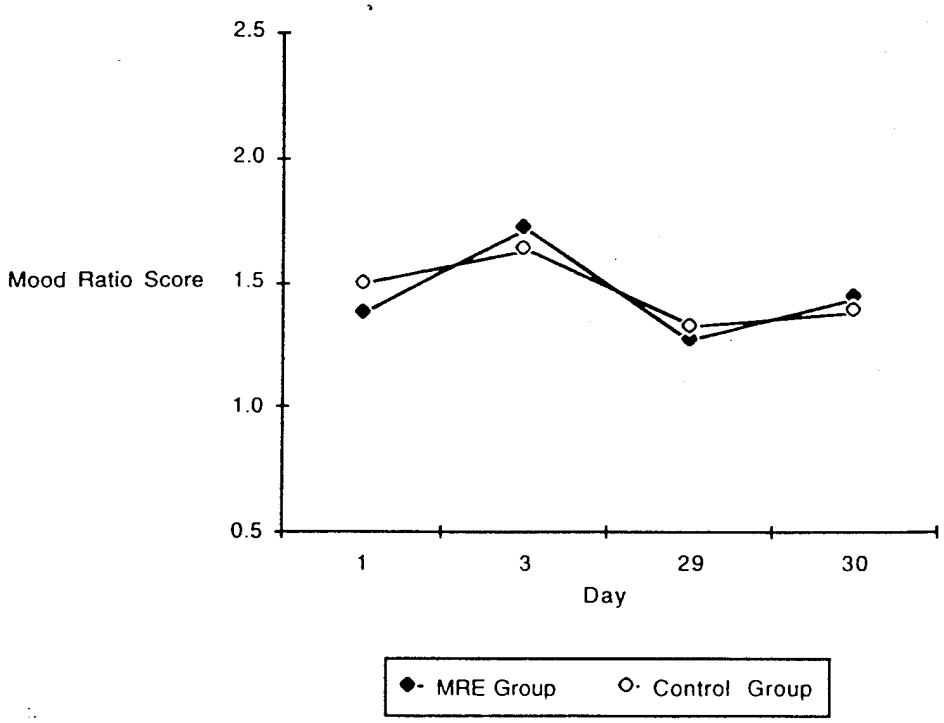


Figure 10. Average mood ratio (positive:negative) scores following road marches.

BIOCHEMICAL ASSESSMENT OF NUTRIENT STATUS

Serum metabolic markers were relatively stable across all three measurements periods (Table 7). Glucose and glycerol values were slightly reduced in both experimental groups in the last sample, compared to previous samples, possibly indicative of a reduced energy intake. At the end of the study, reduced glycerol levels (<60 µmol/L) were more prevalent in the control group (23%) than the MRE group (6%). Total proteins and albumin were normal for all individuals throughout the experiment, indicating the absence of any gross malnutrition; marked increases in proteins would have been indicative of dehydration. Acute markers of metabolic stress such as β-hydroxybutyrate and lactate remained within normal limits for all men, indicating the absence of ketosis or lactic acidosis within the recent (~hours) period preceding the blood sampling. Creatinine and BUN remained within normal limits, even though nitrogen balance increased substantially during this experiment (reported in the next section).

Baseline serum lipids were within the desirable range for healthy young men (i.e., cholesterol < 200 mg/dL, LDL-cholesterol < 130 mg/dL, HDL-cholesterol > 35 mg/dL) as shown in Table 8. A change in these parameters would have most likely reflected an insult to the liver, rather than any effect of dietary intake over this relatively short period of time. Thus, it is not surprising that intakes of cholesterol for the control group which were double the MRDA goal of <300 mg/day had a negligible effect on serum cholesterol with only a 30 day exposure. A significant reduction in serum triglycerides for both groups suggests effects of reduced total intakes and/or benefits of increased physical activity during this field exercise. This is consistent with the observed reductions in body fat stores.

Liver function tests were normal and demonstrated no clinically meaningful change over the course of the experiment (Table 9). These, and other acute metabolic markers are listed in Table 7. The normal enzyme levels indicate that there was no muscle damage related to high intensity physical activity within 24-48 hours preceding the blood sampling. The various enzymes measured range from specific markers of liver diseases (e.g. γ-glutamyl transferase) to nonspecific markers of cellular injury (e.g. lactate dehydrogenase). Generally, a value for AST or ALT several times over the normal upper limit (e.g. >200 U/L) would generate clinical interest; thus, statistically significant increases within the normal range are not meaningful in the context of this study.

Table 7 Acute metabolic markers

Parameter	Normal range	Group	Baseline	Midpoint	End
Glucose	70-105 mg/dL	Control MRE	92.6*± 9.9[a] 96.4*± 6.6[a]	86.9*±8.6[b] 93.9*±8.2[ab]	83.0*±7.0[b] 90.7*±7.8[b]
BUN	10-20 mg/dL	Control MRE	16.2 ± 3.6[a] 16.1 ± 3.7[a]	16.2*±3.2[a] 13.7*±3.2[b]	19.0*±3.6[b] 15.2*±3.5[ab]
Creatinine	0.6-1.3 mg/dL	Control MRE	1.2*± 0.14 1.1*±0.15[a]	1.2 ±0.11 1.3 ±0.18[b]	1.1±0.13 1.2±0.18[ab]
Uric Acid	2.6-7.2 mg/dL	Control MRE	6.6 ± 1.2[a] 6.4 ± 1.0	5.5 ±1.0[b] 5.9 ±0.9	5.6*±0.9[b] 6.1*±1.0
Total Protein	6.7-8.2 g/dL	Control MRE	7.4 ±0.36 7.5 ±0.42	7.5 ±0.40 7.5 ±0.40	7.5±0.43 7.5±0.43
Albumin	3.2-5.5 g/dL	Control MRE	4.6 ±0.23 4.7 ±0.28	4.7 ±0.23 4.8 ±0.28	4.7±0.31 4.8±0.26
Glycerol	61-232 umol/L	Control MRE	114*±22.5[a] 97*±32.9	102±30.5[a] 110±37.9	84*±30.5[b] 103*±34.5
NEFA	0.1-0.6 mmol/L	Control MRE	0.4±0.14 0.4±0.23	0.4 ±0.23 0.5 ±0.28	0.4±0.27 0.5±0.20
β-hydroxy-butyrate	<1.0 mg/dL	Control MRE	0.18±0.09 0.21±0.13	0.17±0.08 0.18±0.11	0.21±0.18 0.22±0.11
Lactate	0.5-2.0 mmol/L	Control MRE	2.0±0.53[a] 1.8±0.47	2.3±0.66[b] 2.0±0.69	2.1±0.52[ab] 2.1±0.63

All values are $\bar{x}$±SD

*denotes significant differences between groups, $p<0.05$

Letters within groups denote significant differences between timepoint, $p<0.05$

Table 8 Serum lipids

Lipid	Desirable range	Group	Baseline	Midpoint	End
Cholesterol	<200 mg/dL	Control MRE	169±30 172±31	166±30 165±30	170±33 166±33
Triglycerides	<150 mg/dL	Control MRE	112±39[a] 115±55[a]	99±34[a] 98±24[ab]	73±28[b] 81±21[b]
HDL-chol	>35 mg/dL	Control MRE	40± 8 37±10	41*±8 36*±7	44*±10 39*± 7
LDL-chol	<130 mg/dL	Control MRE	110±29 116±29	108±30 114±29	115±32 114±31

All values are $\bar{x}$± SD

*denotes significant difference between groups, $p<0.05$

Letters within groups denote significant differences between timepoint, $p<0.05$

Table 9 Liver function tests

Enzyme	Normal range	Group	Baseline	Midpoint	End
Total Bilirubin	0.2-1.0 mg/dL	Control MRE	0.8±0.4 0.8±0.2	0.9±0.4 0.9±0.3	1.1±0.7 1.0±0.3
LDH	91-180 U/L	Control MRE	130±21[a] 133±33[a]	144±45[ab] 132±34[a]	159±37[b] 152±28[b]
AST	10-42 U/L	Control MRE	24±6[a] 22±6[a]	26±11[ab] 24±12[a]	31±16[b] 32±22[b]
ALT	10-60 U/L	Control MRE	13±6[a] 13±4[a]	16±5[ab] 15±6[a]	18±6[b] 19±9[b]
GGT	7-64 U/L	Control MRE	21±14 21±11[a]	18±11 17± 7[b]	19±10 15± 5[b]

All values are $\bar{x}$ ± SD

*denotes significant difference between groups, $p<0.05$

Letters within groups denote significant differences between timepoint, $p<0.05$

Normal iron status was maintained over the 30 days of MRE feeding. Iron, iron binding capacity (TIBC) and ferritin values were stable across the three blood sampling periods, indicating no change in iron stores (Table 10). Hematocrit and hemoglobin also remained within normal limits. Three soldiers in the MRE group had low serum iron (<50 µg/dL) at the start of the study, compared to four men at the end of the study. Two men in the MRE group began the study with low hemoglobin (<14 g/dL) and all were within the normal range at the end of the study.

Serum electrolytes and minerals all remained within normal limits (Table 11). Since most of these are critical to normal physiological function, concentrations are tightly regulated; a departure from normal values would signify a serious condition such as severe heat stress. The small changes in parameters such as potassium concentrations probably reflect effects of phlebotomy technique and whole blood handling and processing.

Serum indices of vitamin status indicated no deficiencies (Table 12). Several of these indices, such as red cell concentrations of folate and red cell enzyme responses to vitamin exposure (an *increased* stimulation or activity coefficient indicates reduced vitamin activity) are more sensitive markers of a chronic deficiency than direct measurement of serum vitamin concentrations. Generally, a marked absence of the vitamin in the diet or a longer period of exposure to a marginally deficient diet (~months-years) would be necessary to suppress serum levels. For several vitamins (thiamin, Vitamin B_{12}, and folate), status tended to actually improve with Army rations (both MRE and control groups). This may have also been the case for Vitamin C; however, extraordinarily low levels at the start of the experiment can only be reasonably explained by a methodological problem in the handling and processing of the blood specimens. Intakes of Vitamin C and thiamin were >200% of the MRDA for both control and MRE groups and serum ascorbic acid would be expected to increase during the study. Folate and Vitamin B_{12} were notable exceptions in the list of vitamin and mineral intakes relative to the MRDA; intakes of each of these vitamins over the 30 day experiment were ~half of the MRDA. However, this intake appears to be adequate for moderately active men for this period of time. Vitamin D_3 was the only vitamin which demonstrated a decrease over the 30 days of the study, and this decline was not different between control and MRE groups. Although retinol demonstrated a trend towards a decline during the study, no men in the MRE group and only one man in the control group declined to <30 µg/dL by the end of the study.

Table 10 Iron status

Parameter	Normal range	Group	Baseline	Midpoint	End
Iron	50-160 ug/dL	Control MRE	71.0 ± 21[a] 78.0±24	72.0*±27[a] 95.0*±34	100*± 33[b] 82.0*±29
TIBC	250-450 µg/dL	Control MRE	316±36 n.s. 313±35 n.s.	not done not done	319*±49 297*±31
Ferritin	22-447 ng/mL	Control MRE	82.0*±43 126*± 73	69.0*±37 103*± 63	73.0*±46 105.0*±63
Hematocrit	39-49%	Control MRE	45.1±3.0 45.6±2.6	45.3±2.6 45.3±2.3	45.6±3.1 45.9±2.6
Hemoglobin	13.5-17.5 g/dL	Control MRE	15.4±1.0 15.4±1.0	15.8±0.2 15.6±0.1	15.8±1.3 15.6±0.7

Table 11 Serum minerals and electrolytes

Mineral or Electrolyte	Normal range	Group	Baseline	Midpoint	End
Sodium	135-145 mmol/L	Control MRE	141 ± 1.8 142 ± 1.7	140 ± 2.0 140 ± 2.4	140 ± 2.1 141 ± 1.6
Potassium	3.8-5.0 mmol/L	Control MRE	4.3* ± 0.4 4.5* ± 0.4[a]	4.3±0.4 4.3±0.3[b]	4.4*±0.3 4.2*±0.3[b]
Chloride	101-111 mmol/L	Control MRE	106±1.5[a] 106±1.9[a]	104±2.2[b] 105±2.7[ab]	104±2.3[b] 104±1.8[b]
Calcium	8.4-10.2 mg/dL	Control MRE	9.9±0.3[a] 10.0±0.3	10.1±0.3[b] 10.2±0.4	10.1±0.3[b] 10.2±0.3
Phosphorous	2.5-4.6 mg/dL	Control MRE	4.7*±0.5[a] 4.2*±0.5	4.6±0.4[a] 4.4±0.5	4.3±0.5[b] 4.4±0.6
Magnesium	1.8-2.5 mg/dL	Control MRE	2.3±0.12[a] 2.2±0.15	2.2±0.12[a] 2.3±0.17	2.2±0.13[b] 2.2±0.16

All values are $\bar{x} \pm SD$

*denotes significant difference between groups, $p < 0.05$

Letters within groups denote significant differences between timepoint, $p < 0.05$

Table 12 Indices of vitamin status.

Vitamin	Normal range	Group	Baseline	Mid-point	End
Vitamin A (retinol)	30-80 ug/dl	Control MRE	45.0* ± 6.0 54.0* ± 9.0[a]	43.0 ± 6.0 43.0 ± 4.0[b]	46.0 ± 9.0 44.0 ± 6.0[b]
Thiamin	0-15% activation	Control MRE	7.8 ± 5.0[ab] 8.4 ± 6.5	7.8 ± 5.6*[a] 6.9 ± 4.8	5.2 ± 2.5[b] 5.4 ± 3.3
Riboflavin	1.0-1.4 act coeff.	Control MRE	1.25 ± 0.14 1.26 ± 0.11	1.24 ± 0.12 1.27 ± 0.10	1.23* ± 0.1 1.31* ± 0.1
Vitamin B_6 (pyridoxal)	< 2.0 act coeff.	Control MRE	1.99 ± 0.19 2.05 ± 0.16[a]	1.95 ± 0.17 1.96 ± 0.11[b]	1.96 ± 0.15 1.95 ± 0.12[b]
Vitamin B_{12} (cobalamin)	74-517 pmol/L	Control MRE	477 ± 150 459 ± 159	498 ± 170 511 ± 165	541 ± 172 486 ± 172
Erythrocyte folacin	> 160 ng /mL cells	Control MRE	183 ± 58*[a] 183 ± 49*[a]	101 ± 62*[b] 98 ± 62*[b]	230 ± 92[c] 201 ± 53[a]
Vitamin C (ascorbate)	> 3 mg/L	Control MRE	0.2 ± 0.3[a] 1.0 ± 1.3[a]	4.0 ± 1.9[b] 5.0 ± 1.8[b]	4.0 ± 1.9[b] 6.0 ± 2.0[c]
Vitamin D (25-OH-D_3)	13-52 ng/ml	Control MRE	44 ± 13[a] 45 ± 10[a]	46 ± 20[a] 38 ± 14[ab]	34 ± 10[b] 33 ± 22[b]

All values are $\bar{x}$ ± SD; *p < .05.

*denotes significant difference between groups, p < 0.05

Letters within groups denote significant differences between timepoint, p < 0.05

Normal ranges based on Sauberlich (1984), Teitz (1990), and on baseline values obtained in a previous Army study (Moore et al. 1992).

HYDRATION STATUS

Hydration status as indicated by urine specific gravities (Figure 11) did not indicate any problems with dehydration. There were a few isolated incidences of high specific gravities on some days but nothing that ever became a pattern. Mean fluid intake was 4.2 liters/d in the MRE group and 3.9 liters/d in the control group.

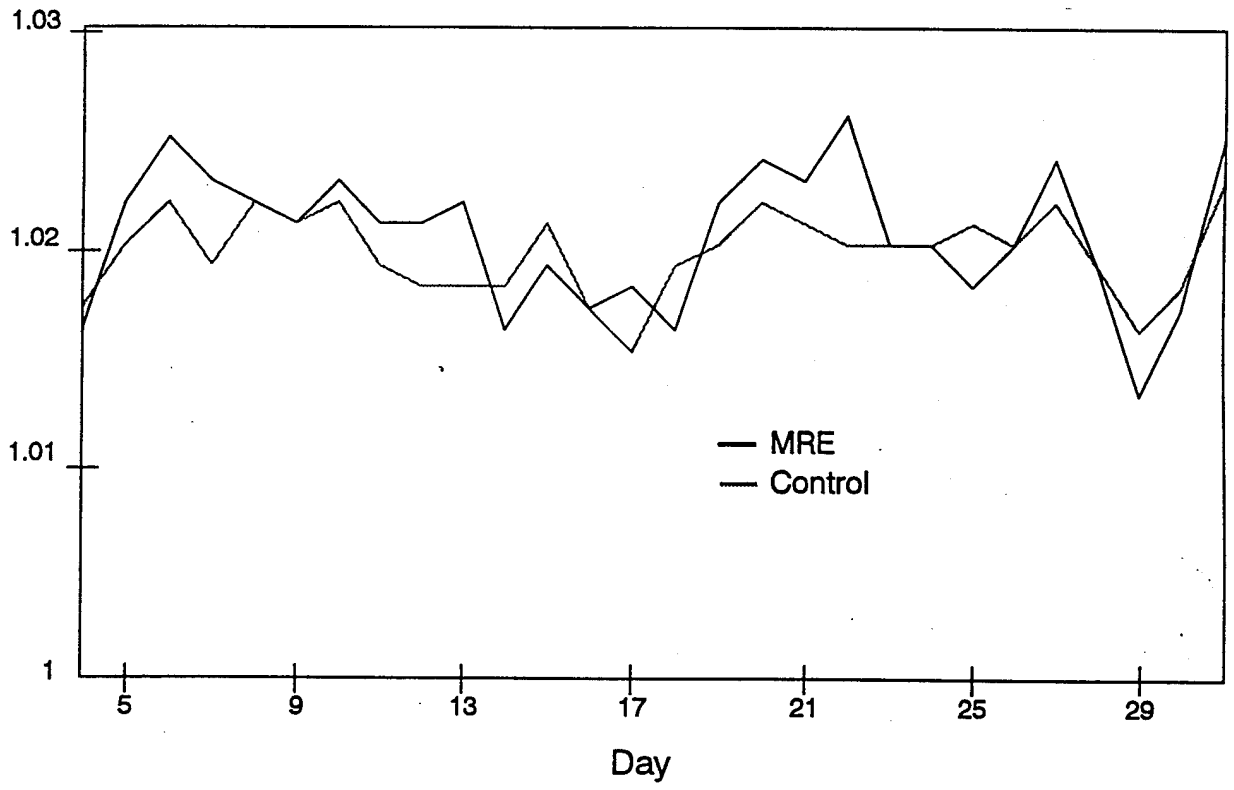


Figure 11 Daily mean urine specific gravity by groups

NITROGEN BALANCE

Figure 12 shows that nitrogen balance was positive and slightly increased over the study. This result corresponds to the fact that energy intake slightly increased and the rate of weight loss decreased, especially in the control group, over the course of the study.

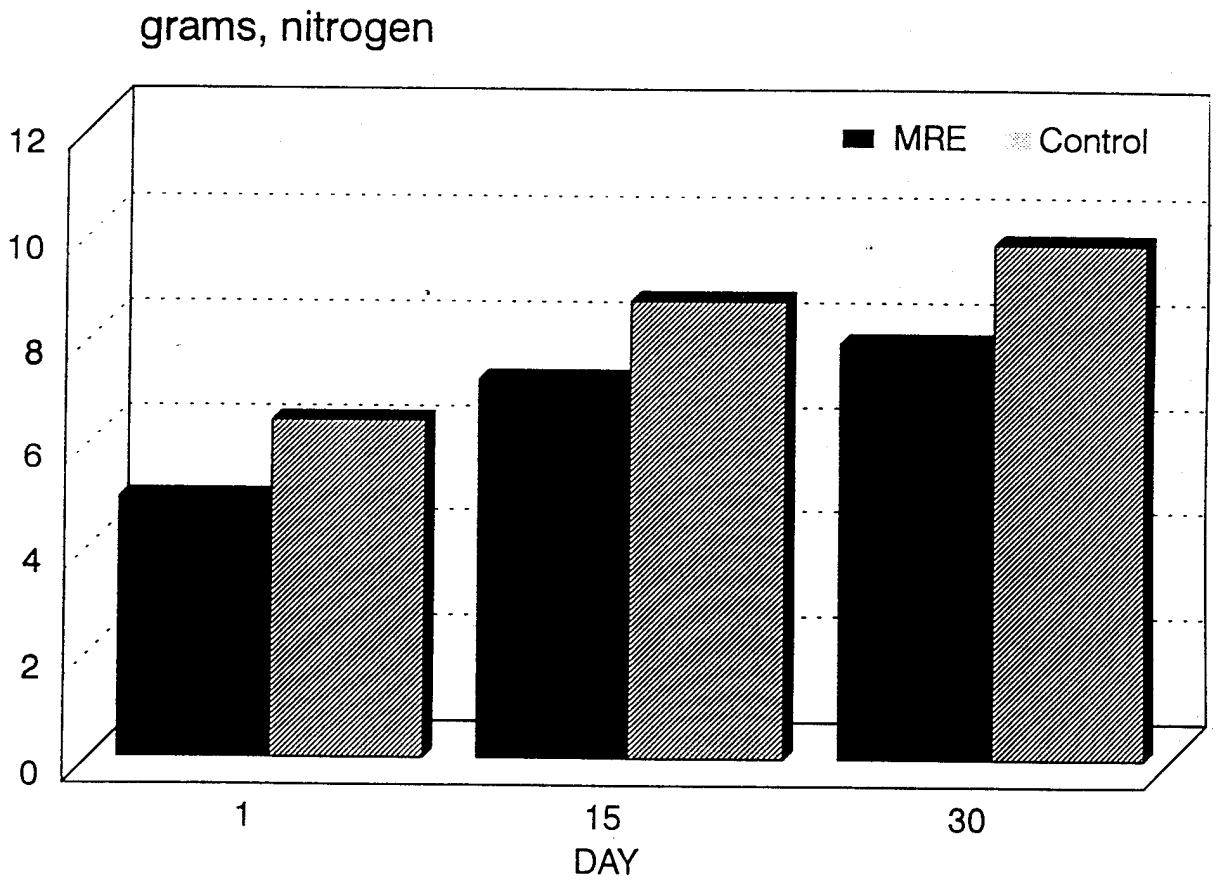


Figure 12 Nitrogen balance (24h) at the beginning, midpoint, and end of the study

DAILY ACCEPTABILITY RATINGS

Daily ratings for individual food items in the Meal, Ready-to-Eat are presented in Table 13. The soldiers were asked to rate each food item on a 9-point hedonic scale where 1 corresponded to 'dislike extremely', 5 corresponded to 'neutral' and 9 corresponded to 'like extremely' (Peryam and Giradot, 1952). Overall, from both groups, the MRE received ratings of 'neutral' or better. The control group ratings tended to be slightly lower than the MRE group ratings.

Entree ratings in the MRE group ranged from a high of 7.4 (like moderately) for the Ham Slice to 5.3 (neutral) for Corned Beef Hash, which was the lowest rating for any item by the MRE group. In the control group, Spaghetti with Meat Sauce at 7.2 was the highest rated entree, while Chicken ala King at 5.1 was the lowest. With the exception of Potato au Gratin, in both groups every item was rated 6.0 (like slightly) or better. In the control group, Potato au Gratin was the lowest rated item at 4.7 (neutral). M&M's received the highest rating in both groups. The only significant differences occurred for Omelet with Ham and Caramel which were rated higher by the MRE group, and Chocolate Nut Cake which was rated higher by the control group.

The individual items were lumped into food groups and the mean ratings are also presented in Table 13. The food groups received ratings of 6.1 (like slightly) or better. The Entrees and Starches received the lower ratings, while the Candy received the highest ratings. There were no significant differences between the groups.

Daily ratings were also examined for significant changes in acceptability over time. A mean daily rating for each food item for each group was calculated correcting for each subject to get only one vote for each item each day. A mean daily ration rating was also calculated where every subject got one vote for whichever items they consumed in a day (i.e., all subjects and all items were averaged into one value per day for each food group). Overall, the control group's ratings tended to be slightly lower than the MRE group's ratings but had greater variability, often switching from above to below the MRE group and back again on a daily basis. There were no significant changes over time.

Table 13 Mean Food Item & Food Group Ratings for the MRE (Daily Ratings)

	MRE (n)	Control (n)	t-test
Entrees	**6.5 ±1.08 (37)**	**6.1 ±1.11 (34)**	**n.s.**
Ham Slice	7.4 ±1.22 (35)	6.8 ±1.85 (25)	n.s.
Spaghetti w/Meat Sauce	7.1 ±1.68 (36)	7.2 ±1.34 (27)	n.s.
Beef Stew	7.1 ±1.16 (34)	6.7 ±1.68 (26)	n.s.
Tuna with Noodles	6.6 ±1.19 (30)	6.2 ±1.67 (28)	n.s.
Meatballs, Rice & Sauce	6.6 ±1.54 (32)	6.7 ±1.56 (23)	n.s.
Chicken and Rice	6.4 ±1.77 (29)	5.8 ±1.87 (22)	n.s.
Pork w/Rice, BBQ Sauce	6.4 ±1.81 (34)	6.4 ±1.30 (24)	n.s.
Chicken Stew	6.3 ±1.61 (32)	5.9 ±1.61 (23)	n.s.
Omelet w/Ham	6.3 ±1.44 (31)	5.2 ±2.14 (19)	p<0.05
Chicken a la King	6.0 ±1.65 (31)	5.1 ±2.02 (23)	n.s.
Escalloped Pot. w/Ham	5.9 ±2.06 (29)	6.5 ±1.47 (19)	n.s.
Corned Beef Hash	5.3 ±1.67 (28)	5.2 ±2.26 (21)	n.s.
Starches	**6.5 ±1.31 (37)**	**6.3 ±1.53 (34)**	**n.s.**
Pouch Bread	7.1 ±1.69 (36)	7.5 ±1.26 (14)	n.s.
Crackers	6.8 ±1.60 (35)	6.6 ±1.31 (34)	n.s.
Potato au Gratin	5.5 ±1.50 (31)	4.7 ±2.50 (21)	n.s.
Spreads	**7.2 ±1.31 (37)**	**6.8 ±0.96 (34)**	**n.s.**
Peanut Butter	7.4 ±1.30 (36)	6.9 ±1.17 (31)	n.s.
Cheese Spread	7.2 ±1.69 (36)	7.0 ±1.32 (31)	n.s.
Jelly	7.1 ±1.38 (35)	6.6 ±1.56 (29)	n.s.
Fruit	**7.0 ±1.39 (34)**	**6.5 ±1.52 (30)**	**n.s.**
Applesauce	7.5 ±1.12 (30)	7.8 ±1.63 (19)	n.s.
Peaches	6.4 ±2.19 (27)	6.2 ±1.80 (27)	n.s.
Dessert	6.6 ±1.20 (36)	6.8 ±0.92 (34)	n.s.
Choc. Covered Cookie	7.4 ±1.27 (31)	7.3 ±1.09 (28)	n.s.
Choc. Nut Cake	6.8 ±1.87 (29)	7.6 ±1.04 (28)	p<0.05
Cherry Nut Cake	6.6 ±1.55 (25)	6.2 ±1.70 (20)	n.s.
Maple Nut Cake	6.5 ±1.62 (23)	6.1 ±1.63 (25)	n.s.
Oatmeal Cookie Bar	6.5 ±1.67 (29)	6.7 ±1.47 (25)	n.s.
Brownie	6.3 ±1.63 (30)	6.7 ±1.49 (31)	n.s.
Cold Drinks	**7.3 ±1.26 (37)**	**7.0 ±0.85 (27)**	**n.s.**
Beverage Base Powder	7.2 ±1.25 (36)	7.0 ±0.85 (27)	n.s.
Hot Drinks	**7.3 ±1.63 (28)**	**6.5 ±2.06 (24)**	**n.s.**
Coffee	7.3 ±1.50 (22)	6.2 ±2.33 (13)	n.s.
Cocoa	7.2 ±1.67 (19)	6.8 ±1.83 (17)	n.s.
Creamer/Sugar	**7.1 ±2.07 (26)**	**6.7 ±1.60 (22)**	**n.s.**
Sugar	7.2 ±2.12 (25)	7.1 ±1.25 (21)	n.s.
Non-Dairy Creamer	7.0 ±1.99 (14)	6.0 ±2.57 (13)	n.s.
Candy	**7.7 ±1.12 (37)**	**7.4 ±0.81 (34)**	**n.s.**
M&M	8.1 ±1.19 (35)	8.0 ±0.87 (28)	n.s.
Caramel	7.8 ±1.11 (35)	7.2 ±0.81 (30)	p<0.05
Tootsie Roll	7.8 ±1.32 (34)	7.7 ±0.83 (30)	n.s.
Charms	7.7 ±1.34 (27)	7.0 ±1.05 (23)	n.s.
Gum	7.3 ±1.34 (33)	6.9 ±1.16 (31)	n.s.
Seasoning	**7.2 ±1.30 (31)**	**6.8 ±1.18 (25)**	**n.s.**
Tabasco Sauce	7.8 ±1.29 (25)	7.1 ±1.34 (23)	n.s.
Salt	7.0 ±1.52 (20)	6.4 ±1.17 (15)	n.s.

Table 14 Mean Food Item and Food Group Ratings for the MRE (Final survey)

	MRE	(n)	Control	(n)	t-test
Entrees	**5.8 ±1.10**	**(34)**	**5.7 ±1.12**	**(32)**	**n.s.**
Spaghetti w/ Meat Sauce	7.5 ±1.77	(33)	7.6 ±1.62	(29)	n.s.
Ham Slice	7.2 ±1.62	(33)	6.3 ±1.97	(27)	p<0.05
Beef Stew	6.9 ±1.83	(33)	6.5 ±1.94	(29)	n.s.
Meatballs, Rice & Sauce	6.3 ±1.94	(32)	6.8 ±1.79	(26)	n.s.
Chicken and Rice	5.8 ±2.38	(32)	5.7 ±2.01	(27)	n.s.
Pork w/Rice, BBQ Sauce	5.8 ±2.12	(32)	5.6 ±2.11	(27)	n.s.
Tuna w/ Noodles	5.8 ±2.11	(32)	6.4 ±1.65	(30)	n.s.
Chicken Stew	5.4 ±2.15	(32)	5.4 ±2.31	(27)	n.s.
Omelet w/Ham	5.3 ±2.37	(31)	3.7 ±2.46	(25)	p<0.05
Chicken a la King	4.5 ±2.61	(32)	3.7 ±2.46	(29)	n.s.
Escalloped Pot. w/Ham	4.5 ±2.65	(30)	4.4 ±2.16	(26)	n.s.
Corned Beef Hash	4.0 ±2.28	(31)	4.0 ±2.28	(29)	n.s.
Starches	**4.7 ±1.72**	**(34)**	**5.3 ±1.46**	**(32)**	**n.s.**
Crackers	6.7 ±1.81	(34)	6.9 ±1.34	(32)	n.s.
Potato au Gratin	4.5 ±2.65	(30)	3.0 ±2.18	(27)	n.s.
Spreads	**7.4 ±1.38**	**(34)**	**6.8 ±1.12**	**(32)**	**p<0.05**
Cheese Spread	7.5 ±1.69	(34)	7.1 ±1.22	(32)	n.s.
Peanut Butter	7.6 ±1.69	(34)	7.1 ±1.99	(31)	n.s.
Jelly	7.2 ±1.72	(34)	6.0 ±2.20	(29)	p<0.05
Fruit	**6.3 ±1.83**	**(32)**	**6.2 ±1.80**	**(30)**	**n.s.**
Applesauce	7.4 ±1.61	(31)	6.8 ±1.93	(25)	n.s.
Strawberries	7.1 ±2.10	(8)	7.5 ±2.22	(13)	n.s.
Peaches	5.8 ±2.58	(30)	5.8 ±2.27	(27)	n.s.
Fruit Mix	5.6 ±2.60	(17)	5.9 ±2.61	(20)	n.s.
Pears	5.3 ±2.87	(13)	5.3 ±2.38	(20)	n.s.
Dessert	**6.1 ±1.95**	**(33)**	**6.2 ±1.31**	**(32)**	**n.s.**
Choc. Covered Cookie	7.1 ±2.36	(33)	7.3 ±1.33	(32)	n.s.
Choc. Nut Cake	6.2 ±2.54	(31)	7.7 ±1.18	(30)	p<0.01
Maple Nut Cake	5.9 ±2.41	(29)	5.9 ±1.96	(29)	n.s.
Brownie	5.8 ±2.26	(32)	6.2 ±1.87	(31)	n.s.
Oatmeal Cookie Bar	5.8 ±2.51	(30)	6.2 ±2.42	(29)	n.s.
Cherry Nut Cake	5.5 ±2.43	(25)	5.0 ±2.22	(28)	n.s.
Cold Drinks	**6.7 ±1.65**	**(30)**	**6.2 ±1.58**	**(28)**	**n.s.**
Cherry Beverage	7.4 ±1.57	(28)	6.8 ±1.82	(28)	n.s.
Grape Beverage	6.9 ±1.84	(30)	6.5 ±1.78	(27)	n.s.
Lemon-Lime Beverage	6.5 ±2.06	(29)	5.6 ±2.04	(28)	n.s.
Orange Beverage	6.1 ±2.16	(30)	6.2 ±1.92	(27)	n.s.
Hot Drinks	**7.0 ±2.10**	**(28)**	**6.0 ±2.31**	**(26)**	**n.s.**
Coffee	7.1 ±2.10	(20)	5.4 ±2.26	(20)	p<0.05
Cocoa	7.0 ±2.24	(25)	6.2 ±2.52	(26)	n.s.
Creamer/Sugar	**7.2 ±1.87**	**(27)**	**6.2 ±1.77**	**(27)**	**p<0.05**
Sugar	7.4 ±1.93	(27)	6.5 ±1.72	(27)	n.s.
Non-Dairy Creamer	6.8 ±2.07	(17)	5.1 ±2.34	(15)	p<0.05
Candy	**7.4 ±1.31**	**(34)**	**7.2 ±1.17**	**(32)**	**n.s.**
M&M	8.2 ±1.48	(34)	8.0 ±1.17	(31)	n.s.
Tootsie Roll	7.9 ±1.63	(34)	7.4 ±1.68	(32)	n.s.
Caramel	7.6 ±1.50	(34)	7.2 ±1.24	(32)	n.s.
Charms	6.8 ±2.02	(34)	6.2 ±1.98	(30)	n.s.
Gum	6.7 ±1.70	(33)	6.7 ±1.89	(31)	n.s.
Seasoning	**6.9 ±1.92**	**(29)**	**6.7 ±1.77**	**(27)**	**n.s.**
Tabasco Sauce	7.3 ±2.19	(27)	6.9 ±2.12	(27)	n.s.
Salt	6.4 ±2.00	(25)	6.0 ±1.83	(21)	n.s.

Final Questionnaire Acceptability Ratings

Ratings from the Final Questionnaire (Appendix F) for individual food items in the Meal, Ready-to-Eat are presented in Table 14. Overall, the ratings were much lower than the daily field ratings. In the MRE group, of the entrees, Spaghetti with Meat Sauce received the highest rating at 7.5 (like moderately), while Corned Beef Hash at 4.0 (dislike slightly) was the lowest rated item in the ration. In the control group, of the entrees, Spaghetti with Meat Sauce also received the highest rating at 7.6 and Omelet with Ham and Chicken ala King both received the lowest rating at 3.7. With the exception of Potato au Gratin, the remainder of the items received ratings of 5.0 (neutral) or better. Potato au Gratin was the lowest rated item in the control group at 3.0 (dislike moderately). M&M's was the item in the ration rated highest by both groups. The ratings from the control group tended to be lower than the MRE group's ratings. Ham Slice, Omelet with Ham, Jelly, Coffee and Non-Dairy Creamer were all rated higher by the MRE group while Chocolate Nut Cake was rated higher by the control group.

The individual items were combined into food groups and the mean rating for each food group is also presented in Table 14. Overall, the food groups received ratings of 4.7 (neutral) or better by both groups. In both groups, Starches were the lowest rated food group, while Candy was the highest rated. In the MRE group, Spreads were rated as high as Candy. The MRE group rated Spreads and Creamer and Sugar significantly higher than the control group did.

Midpoint and Final Questionnaires

Table 15 contains summary ratings for overall acceptability, appearance and variety from the Midpoint and Final Questionnaires, using a 9-point scale. There were no significant differences in answers between the groups or the questionnaires. When asked to rate, overall, how much they liked the rations and how much they liked the appearance, the response corresponded to 'like slightly'. Both groups had 'neutral' feelings about the available variety. Although there were no significant differences, on each question the mean response either stayed the same or was higher on the Final as compared to the Midpoint Questionnaire.

Table 15 Comparison of Ratings for Several Aspects of the MRE from the Midpoint and Final Questionnaires

Rating	Midpoint				Final			
	MRE	n	Control	n	MRE	n	Control	n
Overall Acceptability	5.60 ±1.46	32	5.30 ±1.86	30	5.80 ±1.52	33	5.70 ±1.36	32
Appearance	5.40 ±1.19	32	5.30 ±1.40	30	5.80 ±1.64	34	5.80 ±1.04	32
Variety	4.90 ±1.95	32	5.00 ±1.87	30	5.00 ±1.68	34	5.00 ±1.69	32

** 9 - Point scale: 1 = dislike extremely; 5 = neutral; 9 = like extremely

Table 16 contains summary ratings for portion size of the MRE from the Midpoint and Final Questionnaires. There were no significant differences in answers between the groups or the time periods. Both groups felt that the portion size of the Starches was 'just right', while the rest of the items were 'somewhat too small'. With the exception of Starches and Candy in the control group (rated closer to 'just right' on the Final Questionnaire) the portion rating was less or closer to 'somewhat too small' on the Final Questionnaire as opposed to the Midpoint Questionnaire.

When asked about how many MRE meals a day they usually ate, the MRE group indicated a mean of 2.3 meals on both questionnaires while the control group indicated a mean of 1.1 meals. On both questionnaires, both groups indicated that they 'usually' had enough time to eat their MRE meal.

Table 16 Summary Ratings of Portion Size of the MRE from the Midpoint and Final Questionnaires

Item	Midpoint				Final			
	MRE	n	Control	n	MRE	n	Control	n
Entrees	2.40 ±0.62	32	2.30 ±0.79	30	2.40 ±0.75	34	2.30 ±0.62	32
Starches	2.80 ±0.55	32	2.80 ±0.66	30	2.80 ±0.55	34	2.60 ±0.61	32
Spreads	2.30 ±0.58	32	2.10 ±0.68	30	2.30 ±0.80	34	2.10 ±0.73	32
Fruits	2.10 ±0.77	31	2.20 ±0.87	29	2.20 ±0.73	33	2.30 ±0.82	32
Desserts	2.00 ±0.81	30	2.20 ±0.77	30	2.30 ±0.77	33	2.20 ±0.79	32
Beverages	2.30 ±0.76	32	2.50 ±0.87	29	2.40 ±0.70	33	2.50 ±0.76	32
Candy	2.20 ±0.90	32	2.30 ±1.03	30	2.30 ±0.90	34	2.20 ±0.90	32

mean ± SD

** 5-Point scale: 1 = much too small; 3 = just right; 5 = much too large

When asked on the Final Questionnaire whether any items should be added to or dropped from the ration, there were a variety of answers. In the MRE group, 29% voted for Potato au Gratin and 24% voted for Corned Beef Hash to be dropped. In the control group, 38% voted for Potato au Gratin and 25% voted for Chicken a la King to be dropped. Of items that should be added, Pouch Bread (in every meal), Mustard, Ketchup, Pepper and Pizza were the most popular answers in both groups.

FLAMELESS RATION HEATER QUESTIONNAIRE RESULTS

The Flameless Ration Heater (FRH) questionnaire (Appendix I) was completed by a total of sixty-three test subjects (thirty-three were from the MRE group and thirty were from the control group) at the end of the 30-day study. In general the two groups found the FRH to be between "moderately" and "very easy" to use. The subjects found that the FRH heated the entree to a temperature that they considered to be between warm and hot, and that heating the entree moderately improved its taste. The time it took for the FRH to heat the MRE was found to be between "neither slow nor fast" and "slightly fast." The individual group results were similar to the combined results for the above criteria.

To detect potential problems with the FRH, the subjects were asked to rate problems on a four-point scale. The FRH posed few problems to either test group. Of six potential problems identified, only two were rated by more than 50% of the subjects as being some degree of a problem, i.e., slight, moderate, or large (Table 17). Six percent of the subjects rated smell produced during heating as a large problem. Forty-seven percent of the subjects rated residue produced during heating as a problem to some degree.

In the MRE group, 65% rated burning hands as a problem to some degree while 32% did not consider it a problem. In the control group, the situation was reversed (i.e., more subjects rated it as not a problem (66%) than a problem (34%)). The MRE group marked "smell produced during heating" as a problem more often than the control group (65% vs. 38%). The responses to these two questions were significantly different ($p<.05$) between groups.

Overall, the FRH Questionnaire revealed that if the FRH was packaged with the MRE, it would be used "almost always" to heat the entree. If not packaged with the MRE but issued separately, 85% of the subjects would use the FRH to heat at least one out of every two entrees consumed. Eighteen percent (n=6) of the MRE group said they would not use it because of lack of time, 6% (n=2) because of the bad smell produced, 6% (n=2) because it created a mess, and 3% (n=1) because he would not waste the water. Twenty-two percent (n=7) of the control group said they had no time, (6% (n=2) would not use the FRH because of the bad smell it produced, 6% (n=2) would not waste water, and 13% (n=4) specified other reasons. If not able to use the FRH right away, all but one subject (n=65) answered that they would save it for later (one said he would throw it away).

Table 17 Percentage of combined groups' responses concerning the flameless ration heater

	Degree of Problem			
Potential Heater Problems	**NO**	**SLT**	**MOD**	**LG**
Adding H_2O to Bag	82	15	2	0
Burning Hands	50	38	12	0
FRH Not Heating	80	18	2	0
Smell Produced	48	34	11	6
Water Spilling	69	17	12	2
Residue Produced	56	25	17	2

NO = none; SLT = slight; MOD = moderate; LG = large

ACCESSORY PACKET QUESTIONNAIRE

The Accessory Packet Questionnaire (Appendix H) asked the subjects to rate the importance of eight items in the accessory packet while on a field exercise. Table 18 summarizes the means of the responses by both groups combined and by each group separately. As can be seen, most items were rated between "slightly important" and "moderately important." In the combined means column, only matches and toilet tissue received a rating of 3. There were no significant differences in responses between groups. The results were similar when the groups were separated; i.e., 77% of the subjects in the MRE group and 88% of the control group preferred that the accessory packet items be packed in the MRE.

Table 18 Importance Ratings of Accessory Packet Items by Study Groups

Accessory Pack Items	**Overall** Mean ±SD n = 66	**MRE Group** Mean ±SD n = 34	**Control-Group** Mean ±SD n = 32
Matches	3.1 ± 0.9	3.3 ± 0.8	2.9 ± 0.9
Toilet Tissue	3.1 ± 1.0	3.0 ± 1.1	3.2 ± 0.9
Towelettes	2.8 ± 1.0	2.6 ± 1.1	2.9 ± 1.0
Gum	2.7 ± 1.1	2.6 ± 1.2	2.7 ± 1.0
Instant Coffee	2.5 ± 1.1	2.6 ± 1.2	2.4 ± 1.1
Creamer	2.2 ± 1.1	2.3 ± 1.2	2.0 ± 1.1
Sugar	2.7 ± 1.1	2.9 ± 1.1	2.5 ± 1.1
Salt	2.7 ± 1.1	2.8 ± 1.1	2.6 ± 1.1

* 4-point scale: 1 = "not important"; 2 = "slightly important"; 3 = "moderately important"; 4 = "very important

DISCUSSION

A primary concern for successful mission performance in any field deployment is that soldiers be provided with adequate nutrition in the most convenient and efficient mode. It is important that the MRE, the backbone of the operational field ration system, provide the nutrition necessary to sustain soldiers in a variety of mission scenarios and environments. Table 19 compares the energy intake observed in this study to previous long-term studies (30 days or longer in duration) involving the Army Field Feeding System and the MRE. As revealed in prior studies, energy intake in this study did not fully support weight maintenance; however, the rate of weight loss was slower than in previous studies and some of the weight loss was deliberate on the part of overweight soldiers. Current Army ration policy has been based on a recommendation that weight loss should not exceed 3% of initial body weight. The results of this study showed that soldiers consuming hot meals (A rations) along with MREs kept weight loss below 3% of initial body weight. The MRE group reached the 3% body weight loss level by day 21 of the study. This was better than in previous studies where subjects typically reached the 3% weight loss level by day 10. A select group of soldiers wanting to lose weight during this study dieted and reached a 3% weight loss approximately seven days sooner than soldiers not consciously trying to lose weight. This

Table 19 Mean Daily Kilocalorie Intake in Long-term (≥30 days) Field Studies

Ration Type	Current Study	1983[1] MRE Study	1985[2] CFFS Study	1987[3] SOF Study
MRE groups	2462	2189	----	2782
Other groups (Ration mix)	2911 (A/ MRE/ A)	2950 (A/ MRE/ A)	2115 (1 T/ 2 MRE)	1946 (RLW)
			2663 (B/ MRE/ B)	
			3047 (A/ MRE/ A)	

[1] Effects of Prolonged Feeding Meal, Ready-to-Eat (MRE) Operational Rations, 1983.
[2] Combat Field Feeding System - Force Development Test and Experimentation, 1986.
[3] Nutritional Status and Physical Performance of Special Operation Soldiers Consuming the Ration, Lightweight, or the Meal, Ready-to-Eat Military Field Ration During a 30-Day Field Training Exercise, 1987.

illustrates one problem with using weight loss as the endpoint for the adequacy of a ration. The current emphasis on weight control as part of a program to improve the health and fitness of soldiers means that 20-35% of soldiers in any random sample will be approaching their weight limits (based on 1994 Health Risk Appraisal statistics) and may deliberately restrict intakes. The field environment helps to isolate soldiers from some factors influencing overweight such as fast food availability and is seen by some soldiers as an opportunity to lose weight.

The three percent weight loss limit may be more restrictive than necessary. The Army Weight Control Regulation (AR 600-9) recommends a safe level of weight loss as 1-2 pounds per week. An eight pound weight loss (i.e., 2 lbs/wk) for the average soldier in this study would correspond to a loss of 4.5 and 4.7% of initial body weight in the MRE and control groups, respectively. The American Dietetic Association (ADA) *Handbook of Clinical Dietetics* (1992) suggests weight loss in less than six months, as high risk for nutrition intervention. The Committee on Military Nutrition Research reported in their workshop on *Predicting Decrements in Military Performance Due to Inadequate Nutrition* (1986b) that "when sufficient energy and sodium chloride in the presence of adequate vitamin intake are provided to prevent ketosis, dehydration, and hypoglycemia, performance capacity is well maintained under conditions of moderate energy output up to a weight loss of 10% of the control body weight." The average weight loss of 3.8% of initial body weight in the MRE group in this study was within the recommended levels of safe weight loss described in the above references, thus it is important to emphasize the other nutritional and performance status measures of this study in assessing the overall impact of ration consumption on soldiers.

The inability to consume adequate energy to maintain weight was not due to an inadequate supply of food for the soldiers, nor can it be attributed to the absence of any key nutrient or vitamin. In this study, the MRE group consumed only 55% of the energy provided in the rations, while the control group consumed 76% of the energy available in the ration mix provided to them. Investigations into the factors that contribute to voluntary underconsumption must continue in order to develop ration, training, and organizational countermeasures. The proceedings of a symposium on research in this area are currently being prepared by the Committee on Military Nutrition Research.

The weight loss observed in this study was not associated with any adverse metabolic alterations. It was not due to dehydration, as indicated by a normal hydration status in daily urine specific gravities. Most of the weight loss was from body fat stores as indicated by the reduction in percent body fat and the changes in fat mass demonstrated by DEXA measurements. The weight loss and increased fat metabolism also was not profound enough to cause an increase in daily urine ketone levels or major changes in any other metabolic markers.

The soldiers in this study maintained positive nitrogen balance even with the negative energy balance. This occurred because actual protein intake was 100% of the MRDA; if the entire ration had been consumed, soldiers would have received 150% of the MRDA for protein. Although losses of nitrogen in sweat can be important in conditions which include periods of heavy physical activity (Consolazio et al., 1975), the normal serum protein levels and unchanged levels of short-term markers of protein turnover such as TIBC (as an indicator of transferrin levels), indicate that protein intakes were adequate. The relatively high protein content of the rations may help to spare lean body mass stores and to prevent negative nitrogen balance when consumption is inadequate to meet energy needs, as in the case of this study. However, if soldiers ate their entire ration, they would receive more protein than needed. Even in conditions of sustained physical stress (40 days), Krzywicki et al. (1978) demonstrated that 100 grams of protein per day was sufficient to maintain positive nitrogen balance. High protein intake increases urinary water loss in the excretion of nitrogenous wastes. Conceivably, this could compromise hydration in a hot dry environment with limited water availabilty.

Subjects consumed adequate quantities of rations to meet the MRDA for most nutrients. Although intakes of calcium, magnesium, and iron in the MRE group were about 85% of the mean range for their MRDA values, the intakes were above the minimum level of the male MRDA for each nutrient. The fact that the male subjects in this study had a difficult time meeting the mean MRDAs for calcium and iron suggest that females (whose requirements for these nutrients in proportion to energy requirements is higher) are at significant risk for deficient intake of these nutrients. The relatively low carbohydrate intake seen in the MRE group has the potential for impairing soldiers' abilities to perform sustained physical activity, though the road march results of this study did not indicate any decrement in the MRE group's performance. Even in the control group, carbohydrate intake (359 g) was at the low end of the recommended range (350-495 g).

While the intake of some micronutrients was low, blood chemistry indicators of vitamin and mineral status remained within normal ranges and were relatively stable over the course of the study. The intake of vitamin C was 2-2.5 times the MRDA and this was reflected by an apparent increase in serum ascorbate to levels well within the normal range during the study. The baseline values were so low that they suggest an error in sample processing. However, extraordinarily low baseline values which come up to the normal range with military ration consumption have now been noted in at least 3 separate field studies. The substantial fortification of the MRE maintains the micronutrient status in soldiers consuming these rations even when overall energy intake is low (Moore et al. 1992).

The cholesterol intake in the control group was twice the recommended daily level of 300 mg/day, while the MRE group was well within the goal. The cholesterol provided in MREs is close to the recommended daily intake level, and better than the T-ration or A ration levels (Table 20). Most of the cholesterol consumed by the control group was provided by the eggs which were served to-order at breakfast each morning. Usual food consumption prior to commencement of the study was not assessed in this investigation. However, the control group's mean baseline serum cholesterol of 168 mg/dL was well below the recommended upper limit of 200 mg/dL indicating that these young men are still regulating cholesterol metabolism appropriately. Even with the high cholesterol intake, the control group's total cholesterol changed only a few milligrams, and the HDL cholesterol actually increased. These findings suggest that higher cholesterol intake under field conditions with moderate to heavy work does not necessarily pose a threat to blood lipid levels. Education efforts to encourage soldiers to consume less high fat and more high carbohydrate selections at breakfast during field exercises may be beneficial to their long-term cholesterol levels and cardiovascular disease risk.

Field ration acceptability ratings in the range of 6 to 9 are generally interpreted to indicate good soldier acceptance. For example, a rating of 7 or 'like moderately' denotes a very good product (Jezior et al., 1990). In this study, acceptability ratings for the MRE menus were within this range except for three ("Chicken ala King," "Omelet with Ham," and "Potato au Gratin") rated by the control group. The MRE group rated all items above 'like slightly', while the control group had some items rated below the acceptable point. The low rating for

Table 20 Selected Nutrient Content of Operational Rations (Per Meal)

Nutrient	Standard[1]	A Ration[2]	T Ration	MRE VIII	MRE XII[3]
Energy (kcal)	1200	1149[4]	1430[4]	1306	1348
Protein (g)	33	41	59	49	49
CHO (g)	147	149	191	161	167
Fat (g) % of calories	53 (max) 40 (max)	43 34	47 30	52 36	54 36
Cholesterol (mg)	<300 mg/day	239[5]	196	119	119
Sodium (mg)	1666-2333 mg	1691	2468	1813	1823

[1] From AR 40-25, nutritional standards for operational rations; each meal should provide 1/3 of daily nutrient requirements; cholesterol goals reflect current Army nutrition initiatives.
[2] Analysis of A Ration menu from SB 10-163, 14-Day US Army Reserve Component and Field Training Menu.
[3] Full record of nutritive values for MRE XII used in this test is shown in Appendix L.
[4] Total calorie intake will vary depending on foods selected by the soldier.
[5] Based on control group nutrient analysis in this study (2-A rations & 1-MRE).

"Omelet with Ham" by the control group is not surprising since they ate the MRE only for lunch, and "Omelet with Ham" is considered a breakfast item. Soldiers prefer to have breakfast items for breakfast. The MRE group ratings were made throughout the day so it was not possible to compare the two groups' lunch time ratings to see if the MRE group also gave the "Omelet with Ham" lower ratings at lunch.

The other low ratings from the control group may also be attributed to the fact that they ate only one MRE meal a day. Their other two meals were taken in the dining hall where they could choose from a selection of different foods. Their ratings reflect a comparison of the MRE to the fresh food that was available in the dining hall. No ratings of the dining hall foods were collected so it is not possible to make any statistical comparisons which may have explained the wide variability in the daily MRE ratings. It is possible that the variations in the ratings reflected changing conditions in the dining hall.

The final questionnaire ratings for individual food items were lower than the daily field ratings. The lower final questionnaire ratings were typical of other studies (Jezior et al., 1990). Since the final questionnaire was filled out by the same soldiers who gave the daily field ratings, sampling was not a factor. Previous work (Jezior et al., 1990) has shown that final questionnaire ratings are predictably lower than daily field ratings as a result of the subjects rating retrospectively. Such ratings indicate dislike for items they avoided eating, and thus did not rate previously in the field. Thus, daily field ratings were never lower than the ratings on final questionnaires.

On both questionnaires, the soldiers in both groups indicated that they thought the portion sizes should be slightly increased. The intake data revealed that the MRE group consumed only 55% of the available kilocalories provided in the rations. The soldiers typically consumed the entire content of an individual food item from the MRE pouch (i.e., an entire entree or entire cake) once this item was opened. Providing the same kilocalories per MRE meal pouch with fewer but larger individual items could possibly result in an overall increase in total intake. Soldiers would eat the same number of individual items but actually get more calories. Collection of hunger and fullness ratings would have helped to determine whether or not the subjects perceived that they were getting enough to eat.

The three previous studies which fed MREs for at least 30 days found no negative effect on physical and mental performance (Hirsch et al., 1984; CFFS, 1986; Askew et al., 1987). By using road marches as a measure of physical performance, this study attempted to more thoroughly challenge the participants and to provide information on their performance on a specific and critical military task. This study confirms the previous finding that there is no negative effect on physical performance.

Soldiers from both groups exhibited the normal range of reactions to field training and as a group appeared healthy and well-adapted to the situation. Subsistence on MREs did not impair self-perceived health, cognitive behavior, or affective behavior. The incidence of gastrointestinal discomfort and negative moods was low for both groups. Strenuous exercise substantially increased gastrointestinal symptoms and decreased the ratio of positive to negative moods. Soldiers subsisting solely on MREs were not different from those subsisting on cook-prepared meals in their reaction to, or recovery from, strenuous exercise.

This study is consistent with others (Askew et al. 1987; Crowdy et al. 1982; Hirsch et al. 1984; CFFS, 1986) in demonstrating that levels of underconsumption which generate average weight losses as high as 6% in less than 30 days do not degrade health or performance.

Overall, the Flameless Ration Heater (FRH) was well-received by the subjects. The MRE group rated problems in using the FRH more extremely than did the control group. The fact that the MRE group had more opportunities to use the FRH may have impacted their stronger opinions about its use since the potential problems would become more apparent the more often the FRH was used. It would be beneficial to work on further refinements to the FRH to reduce the residue left on MRE packages and to improve the smell released by the FRH when activated. Although the residue is a food-grade material and not hazardous to health, improved aesthetics may improve soldiers willingness to use the FRH thereby increasing the possibility of their consuming MRE entrees.

The results of this study indicate that the MRE XII provided adequate sustenance to soldiers during a 30-day field exercise. In some respects the MRE diet was superior to the control diet (e.g., lower cholesterol and fat intakes). In no measure of health or performance was the MRE less adequate than the control diet, except for lower energy intakes and a greater fat weight loss.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CONCLUSIONS

Weight loss reached the level of 3% of initial body weight by 21 days of sole subsistence on MREs. Although one third of each study group was deliberately attempting to achieve weight loss, the rate of weight loss for the MRE group was higher than for the control group receiving A rations. The weight loss was not due to any identified deficiency in the nutrient composition of the rations. It was caused by underconsumption of the available calories (only 50% of carbohydrates provided were consumed) and a resultant 600 kcal/day energy deficit. For men in this field training exercise, the estimated energy requirement was 3000-3250 kcal/day.

No meaningful change in physical performance, self-perceived cognitive performance, affective behavior, or health was associated with: (a) levels of underconsumption which generated average weight losses of 5% over a 30-day period, (b) subsistence on MREs for 30 days, and (c) living in a field setting for 30 days. Biochemical indices of nutritional status remained within normal ranges for most nutrients and did not impair nutritional status after 30 days of subsistence on MREs. The MRE is a high protein ration, providing nitrogen intakes greater than normal baseline of soldiers in this study and exceeding requirements for this field exercise.

The individual foods in the MRE received acceptable ratings over the 30-day period. There was no significant decline in acceptability over this period. This study indicated that the Flameless Ration Heater was a beneficial tool in a moderate climate with adequate water supply. A majority of responses on the questionnaires indicated that matches, toilet tissue, towelettes, gum, instant coffee, creamer, sugar, and salt were important components of the accessory packet and should be kept in the MRE.


USARIEM
RESEARCH FOR THE SOLDIER

RECOMMENDATIONS

1. The MRE is an adequate ration for sustainment of soldier health and performance over 30 days of continuous use, including during exposure to physical and environmental stressors encountered during field conditions.

2. Longer term use of the MRE is predicted to be inadequate for maintenance of iron and calcium status, particularly in female soldiers, and may require mineral supplements. Research should be conducted to address these issues.

3. Future tests of operational rations should emphasize functional endpoints of adequacy such as biochemical markers of nutritional status and tests of mental and physical status, and place less emphasis on specific weight loss thresholds. A specific inquiry into protein requirements should be conducted using stable isotope methods to assess protein turnover rates. Immunological endpoints should be included as more sensitive and operationally important endpoints of the nutritional adequacy of rations.

4. Research to increase consumption of the MRE should continue since only 55% of the calories available were consumed. At the same time, attention should be given to optimizing the intakes of macronutrients, possibly with an increase in carbohydrate content and a decrease in protein content.

5. As new versions of the MRE are produced, they should be tested in a manner similar to this study to ensure that changes do not inadvertently produce any significant adverse consequence.


USARIEM
RESEARCH FOR THE SOLDIER

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APPENDIX A

VOLUNTEER AGREEMENT AFFIDAVIT

VOLUNTEER AGREEMENT AFFIDAVIT

For use of this form, see AR 70-25; the proponent agency is OTSG

PRIVACY ACT OF 1974

Authority: 10 USC 3013, 44 USC 3101, and 10 USC 1071-1087

Principle Purposes: To document voluntary participation in the Clinical Investigation and Research Program. SSN and home address will be used for identification and locating purposes.

Routine Uses: The SSN and home address will be used for identification and locating purposes. Information derived from the study will be used to document the study, implementation of medical programs, adjudication of claims, and for the mandatory reporting of medical conditions as required by law. Information may be furnished to Federal, State and local agencies.

Disclosure: The furnishing of your SSN and home address is mandatory and necessary to provide identification and to contact you if future information indicates that your health may be adversely affected. Failure to provide this information may preclude your voluntary participation in this investigational study.

PART A(1) - VOLUNTEER AFFIDAVIT

Volunteer Subjects in Approved Department of the Army Research Studies

Volunteers under the provisions of AR 40-38 and AR 70-25 are authorized all necessary medical care for injury or disease which is the proximate result of their participation in such studies.

I, _____, SSN _____.

having full capacity to consent and having attained my _____ birthday, do hereby volunteer/give consent as legal representative for _____ to participate in Nutrienr Intake, Nutritional status, body composition and performance of soldiers consuming the meal, ready-to-eat during a 30-day field training exercise (Research Study) under the direction of CPT Robert J. Moore conducted at Fort Chaffee, Arkansas (Name of Institution).

The implications of my voluntary participation/consent as legal representative, duration and purpose of the research study, the methods and means by which it is to be conducted, and the inconveniences and hazards that may reasonably be expected have been explained to me by Captain Robert J. Moore. Contact telephone(s): AV/DSN 256-4875/4874 or commercial 508-651-4875/4874.

I have been given an opportunity to ask questions concerning this investigational study. Any such questions were answered to my full and complete satisfaction. Should any further questions arise concerning my rights/the rights of the person I represent on study-related injury, I may contact Office of Chief Counsel at US Army Natick Research, Development and Engineering Center (508)651-4322 (Name, Address and Phone Number of Hospital (Include Area Code)).

I understand that I may at any time during the course of this study revoke my consent and withdraw/have the person I represent withdrawn from the study without further penalty or loss of benefits; however, if the person I represent may be required (military volunteer) or requested (civilian volunteer) to undergo certain examination if, in the opinion of the attending physician, such examinations are necessary for my/the person I represent's health and well-being. My/the person I represent's refusal to participate will involve no penalty or loss of benefits to which I am/the person I represent is otherwise entitled.

PART A (2) - ASSENT VOLUNTEER AFFIDAVIT (MINOR CHILD)

I, _____, SSN _____ having full capacity to consent and having attained my _____ birthday, do hereby volunteer for _____ to participate in _____ (Research Study) under the direction of _____ conducted at _____ (Name of Institution).

(Continue on Reverse)

PART A(2) - ASSENT VOLUNTEER AFFIDAVIT (*MINOR CHILD*) *(Cont'd.)*

The implications of my voluntary participation; the nature, duration and purpose of the research study; the methods and means by which it is to be conducted; and the inconveniences and hazards that may reasonably be expected have been explained to me by

_____

I have been given an opportunity to ask questions concerning this investigational study. Any such questions were answered to my full and complete satisfaction. Should any further questions arise concerning my rights I may contact

_____

at _____

(Name, Address, and Phone Number of Hospital (Include Area Code))

I understand that I may at any time during the course of this study revoke my assent and withdraw from the study without further penalty or loss of benefits; however, I may be requested to undergo certain examination if, in the opinion of the attending physician, such examinations are necessary for my health and well-being. My refusal to participate will involve no penalty or loss of benefits to which I am otherwise entitled.

_____

PART B - TO BE COMPLETED BY INVESTIGATOR

INSTRUCTIONS FOR ELEMENTS OF INFORMED CONSENT. *(Provide a detailed explanation in accordance with Appendix E, AR 40-38 or AR 70-25.)* You are being asked to participate in a nutrition research study which will be conducted while you are engaged in your normal field training exercise. The purpose of this study is to determine how well the improved version (Version X or XII) of the Meal, Ready-to-Eat (MRE) meets the nutritional needs of soldiers over a 30-day period of time. There will be two groups of volunters in the study. One group of volunteers will eat only the MRE. If you participate in the study and are in this group, you would eat three MREs daily for up to 30 consecutive days and submit to a series of measurements conducted at various times throughout the study. You will not be permitted to supplement the MRE with food of your own choice - in other words, there will be no pogey bait or other food/drink items allowed for the 30-day period.

Anbther group of volunteers will serve as a control group, and eat the field ration cycle which your Commander has decided to use during this FTX. The control group volunteers will be required to complete the same series of measurements as the soldiers eating MREs and will not be allowed to have pogey bait or other food/drink items for the 30-day period of the study.

If you participate in the study, we will not be able to continuously observe your compliance with the request not to eat pogey bait and other non-issue items. However, you will be asked frequently about your compliance, and you will be asked to report instances where you did not comply so that we can factor that into the data analysis.

All of the things we will ask you to do will be included in the op order for the FTX, and as a result, this study will not interfere with the military training you will be doing.

You will not be permitted to participate in the study if you have recurring back or other muscular or skeletal injuries

I do ☐ do not ☐ *(check one & initial)* consent to the inclusion of this form in my outpatient medical treatment record.

SIGNATURE OF VOLUNTEER	DATE	SIGNATURE OF LEGAL GUARDIAN *(If volunteer is a minor)*
PERMANENT ADDRESS OF VOLUNTEER	TYPED NAME OF WITNESS	
	SIGNATURE OF WITNESS	DATE

or pain, or if you have chronic or acute gastrointestinal problems (such as ulcers, chronic constipation, hemorrhoids).

At the beginning of the study, you will complete a brief questionnaire which asks a series of general questions about you (such as name, age, rank, ethnic background) and your normal lifestyle (tobacco/alcohol use, exercise habits, weight status). We will also measure your height and body weight at this time.

We will ask you to do some things every day for the entire 30 days of the study.

1. You will complete a food diary record card each day. This card will provide information on what foods you ate and how much water you drank. The food records take very little time to complete, and they will be collected each day by a data collector who will review them with you, and then give you one for the next day. This card will be only for the MRE food items you eat each day.

If you are eating non-MRE food such as T-rations or B-rations, then a dietary data collector will estimate how much food you get at each meal, and how much of it you eat or throw away. They will do this by having you show them your tray as you leave the mess line. They will then visually estimate how much of each item you have, but they will not touch or handle your food. When you are done eating, you will go back and show them what you didn't eat, and they will again estimate the portion size. The entire process takes less than 1 minute, and won't interfere with your meal periods.

2. You will also be asked to provide a sample of your first urine each morning. We will do two chemical tests on this sample: specific gravity which is a measure of your hydration status, and total ketones which is a measure of whether you are getting enough calories each day.

3. We will weigh you or you will be asked to weigh yourself (shorts only) on a digital scale which we provide. This weight will be taken each morning.

Three times during the study, we will be making more detailed measurements. The three time periods will occur between days 0 and 3 of the study, between days 9 and 12 of the study, and between days 27 and 30 of the study. The following measurements will be done one time during each of these three periods:

1. We will assess your body composition using three different methods. First, we will obtain girth measurements a 9 sites (neck, two waist sites, hips, above the hips, thigh, biceps relaxed and biceps flexed, and forearm). We will estimate body fat using skinfold measurements taken at four sites (over the biceps, over the triceps muscle on the upper arm, at a point just above the hip bone, and on the upper back). These measurements will be made be a trained technician using a caliper device which will not cause any pain or discomfort.

We will also measure your body composition using a dual energy x-ray absorptiometry (DEXA) device. Using a low-energy x-ray scanner, this machine enables us to measure your body fat, lean body mass and your bone density accurately. You will lie on your back, and the machine will automatically scan the length of your

SIGNATURE OF VOLUNTEER	DATE SIGNED	SIGNATURE OF LEGAL GUARDIAN (if volunteer is a minor)	
PERMANENT ADDRESS OF VOLUNTEER	TYPED OR PRINTED NAME AND SIGNATURE OF WITNESS		DATE SIGNED

body, and a computerized detector will record the x-ray transmissions. The entire test will take 10 minutes. The device will not cause any pain or discomfort. You will be exposed to a small amount of x-ray radiation - which is about the same amount you are naturally exposed to every 6 hours - or about 1/30th of the dose of a conventional chest x-ray.

2. We will also collect 3 blood samples at this time, in order to measure the levels of certain substances which tell us the level of certain nutrients in your body, and also about how stress and physical activity are affecting your muscles. We will take blood samples from a vein by needle puncture of a vein in your arm. There is a small risk of a hematoma or bruise forming at the puncture site, but this will gradually disappear. This procedure will be performed using a sterile technique by a skilled technician. There is a slight risk of infection at the puncture site, but by using aseptic techniques, the chance that this will occur is slight. We will collect about 1.5 ounces or 3 tablespoons of blood.

3. You will also be asked to complete a combined road march and marksmanship task which will measure how well the MREs are able to maintain your ability to do physical work. Before the road march, you will complete a 10 round live-fire marksmanship task. Using the foxhole-supported firing position, you will be provided three rounds with which to zero an M-16 rifle. You will then be given 10 rounds to do the test. The test requires you to fire 2 rounds at each of 5 targets qt 25 meters, in a maximum time of 20 seconds. After the target test, you will be asked to complete an 8-mile road march while carrying a total load of 30% of your body weight in the fastest time possible, without running. Immediately after completing the road march (within 5 minutes), you will repeat the marksmanship test. The marksmanship tests will be conducted by range personnel, and all safety regulations will be followed to prevent accidental injuries.

You will also be asked to complete a neurophysiological symptoms checklist immediately prior to and after the road marches. This is a one-page list of 40 symptoms which you may be experiencing at the time (such as depressed, tired, hungry, thirsty, etc.), and you simply check the intensity of each symptom on a scale of 1 (a little) to 5 (extremely). Completion of the checklist takes less than 3 minutes.

Three times during the study, we will ask you to complete a 2-day long collection of your urine. This requires you to collect all of your urine in plastic containers which we provide. We will then measure a number of substances in your urine which indicate the amount of stress you are under (the hormone cortisol) and if you are undergoing muscle breakdown (total nitrogen, creatinine, and the amino acid 3-methyl histidine). These 2-day urine collections will be conducted approximately between days 1-2, days 8-9, and days 28-29 of the study.

SIGNATURE OF VOLUNTEER	DATE SIGNED	SIGNATURE OF LEGAL GUARDIAN (if volunteer is a minor)	
PERMANENT ADDRESS OF VOLUNTEER	TYPED OR PRINTED NAME AND SIGNATURE OF WITNESS		DATE SIGNED

PART B - TO BE COMPLETED BY INVESTIGATOR (cont'd)

Participation in this study is on a voluntary basis. However, if you choose not to take part or if you choose to withdraw from the study, it will not change the type of food provided to you nor affect your requirement to participate in the 3 unit road marches during the course of the FTX. You may withdraw your participation from the study at any time with no penalty or adverse action taken against you.

The information you give, together with the other information that we will collect, will be treated in the strictest confidence. Only information bearing on your health may be revealed to appropriate medical or Command authorities if your data reveals something important to your health. Information about you may be inspected by officials of the US Army Medical Research and Development Command.

You will not receive any direct benefit from participating in this study, other than to know that you have contributed to the effort to develop acceptable field rations for the US Army.

Before you sign this document, be sure that you have read it and fully understand it. If you have any questions concerning this study please ask so that you have a complete understanding of the nature and details of the study. You may discuss the result of the study, but not until your participation is complete. You will be provided with a copy of this consent document for your information and personal record.

SIGNATURE OF VOLUNTEER	DATE SIGNED	SIGNATURE OF LEGAL GUARDIAN (if volunteer is a minor)	
PERMANENT ADDRESS OF VOLUNTEER	TYPED OR PRINTED NAME AND SIGNATURE OF WITNESS		DATE SIGNED

Reverse of DA FORM 8303-R

APPENDIX B

Data Collection Timeline

FTX	Day of Month	Day of Study	Measurement
Operator training	OCT 4		Blood draw
Road march (Performance eval.)	5	1 (Diet Day 1)	24 hr urine Questionnaire Symptoms checklist
off	6	2	24 hr. urine
Net maintenance	7-11	3	DEXA, body comp Symptoms checklist
off	12		
off	13		
Bridging exercises	14-15		
4 Bay raft	16-17	13	24 hr. urine
5 Bay raft	18	14	24 hr. urine Blood draw DEXA, Mid-point* Questionnaires Symptom checklist*
Night Bridging	19-21	15 (Diet Day 15)	DEXA, Mid-point* Questionnaires Symptom checklist*
off	22		
5 Bay raft	23		
6 Bay raft	24-25		
off	26		
off	27		
7 Bay raft	28-29		
off	30		
off	31		
Night raft	NOV 1	28	24 hr urine
Night raft	2	29	24 hr urine DEXA, body comp Symptoms checklist
Road march (Performance eval.)	3	30 (Diet Day 30)	Final Questionnaire Symptoms checklist
End FTX	4		Blood draw Symptoms checklist

[1] Subject Briefing & Informed Consent were conducted at Ft. Leonard Wood prior to deploying to Ft. Chaffee.

[2] Daily Data Collections included: Food & H_2O Intake, Weight, and first void urine.

* On study days 14 & 15, these measurements were performed on individual subjects on either day 14 or 15 (but not on both days).

APPENDIX C

DEMOGRAPHICS QUESTIONNAIRE

Demographics Questionnaire

1. NAME:_____ 2. RANK:_____ 3. DUTY MOS:_____

4. YEARS IN ARMY:___ 5. AGE:____ 6. SEX: MALE FEMALE

7. EDUCATION:

__NO HIGH SCHOOL
__SOME HIGH SCHOOL
__HIGH SCHOOL GRADUATE
__2-YEAR COLLEGE GRADUATE
__4-YEAR COLLEGE GRADUATE
__POST-GRADUATE DEGREES

8. ETHNIC BACKGROUND

__NON-HISPANIC WHITE
__BLACK
__HISPANIC
__ASIAN
__NATIVE AMERICAN
__POLYNESIAN/PACIFIC ISLANDER

9. SMOKING HISTORY

__DO NOT SMOKE/NOT SMOKED 1 YEAR OR MORE
__QUIT SMOKING WITHIN PAST 12 MONTHS
__SMOKE < 1 PACK DAILY
__SMOKE 1-2 PACKS DAILY
__SMOKE > 2 PACKS DAILY

10. DO YOU USE SMOKELESS TOBACCO PRODUCTS?

DO NOT USE

USE (NAME PRODUCT AND HOW MUCH USED)

11. TYPICAL USE OF ALCOHOL

__DO NOT DRINK
__VERY LIGHT USER (LESS THAN 2 DRINKS PER WEEK)
__LIGHT USER (ABOUT ONE-TWO DRINKS PER DAY)
__MODERATE USER (MORE THAN 2 DRINKS/DAY OR 14 DRINKS PER WEEK)

12. EXERCISE HABITS

HOW MANY TIMES PER WEEK DO YOU EXERCISE FOR MORE THAN 30 MINUTES PER SESSION

WHAT TYPES OF ACTIVITIES DO YOU DO DURING YOUR EXERCISE SESSIONS

13. HEALTH: DO YOU PRESENTLY HAVE ANY CHRONIC MEDICAL CONDITIONS? **yes no**

IF YES, PLEASE INDICATE THEM BELOW.

14. ARE YOU CURRENTLY TAKING ANY PRESCRIPTION MEDICATIONS? yes no

IF YES, PLEASE INDICATE MEDICATIONS.

15. ARE YOU CURRENTLY TRYING TO LOSE WEIGHT? **yes no**

IF YES, HOW MUCH WEIGHT?

16. ARE YOU CURRENTLY TRYING TO GAIN WEIGHT? **yes no**

IF YES, HOW MUCH WEIGHT?

17. ARE YOU PRESENTLY TAKING ANY VITAMIN OR MINERAL SUPPLEMENTS?

IF YES, PLEASE INDICATE BRAND AND DOSAGES (IF KNOWN).

APPENDIX D

FOOD DIARY LOG SHEET

MRE

Name:_____ Group # _____

Subject No._____ Day/Date _____

RATING OF FOOD

Circle the number that best describes how much you Liked or Disliked each food item you ate.
For example: If you Liked the Chicken, Slightly, circle 6.

FOODS EATEN

Circle how much of each item you ate. If you ate an amount that is not listed write it on the line to the right.
For Example: Circle 1/2 if you ate half the Chicken Stew issued.

CODE	FOOD ITEM	AMOUNT EATEN	Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like/Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely	Water Added Y or N
	ENTREES											
11	Pork with Rice in BBQ Sauce	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
12	Corned Beef Hash	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
13	Chicken Stew	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
14	Omelet with Ham	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
15	Spaghetti, Meat & Sauce	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
16	Chicken a la King	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
17	Beef Stew	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
18	Ham Slice	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
19	Meatballs, Rice & Sauce	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
20	Tuna with Noodles	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
21	Chicken & Rice	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
22	Escalloped Potatoes with Ham	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
	STARCHES											
23	Potato au Gratin	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
24	Crackers	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
	SPREADS											
25	Cheese Spread	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
26	Jelly	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
27	Peanut Butter	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
	FRUIT											
28	Apple Sauce	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	___
29	Fruit Mix	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	___
30	Peaches	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	___
31	Strawberries	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	___
32	Pears	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	___
	DESSERT											
33	Chocolate Covered Brownie	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
34	Cherry Nut Cake	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
35	Chocolate Covered Cookie Bar	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
36	Chocolate Nut Cake	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
37	Maple Nut Cake	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
38	Oatmeal Cookie Bar	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	

MRE

FOODS EATEN

Circle how much of each item you ate. If you ate an amount that is not listed write it on the line to the right.
For Example: Circle 1/2 if you ate half the Tootsie Roll issued.

RATING OF FOOD

Circle the number that best describes how much you Liked or Disliked each food item you ate.
For Example: If you Liked the Tootsie Roll Slightly, circle 6

CODE	FOOD ITEM	AMOUNT EATEN	Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like/Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely	Water Added Y or N
	BEVERAGES											
39	Beverage Base Powder	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	___
40	Cocoa Powder	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	___
41	Coffee	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	___
42	Non Dairy Creamer	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
43	Sugar	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
	CANDIES											
44	Tootsie Roll	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
45	Charms	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
46	M & M	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
47	Caramel	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
48	Gum	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
	OTHERS											
49	Tabasco Sauce	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
50	Salt	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
	_____	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	
	_____	1/4 1/2 3/4 1 2 3 ___	1	2	3	4	5	6	7	8	9	

WATER CONSUMPTION

1. Write below the number of canteens of water you consumed at different times today for different purposes. For example, write in 1/4 1/2 3/4 1 2 3.

TIME PERIOD	NUMBER OF CANTEENS		
	Drunk as Plain Water	Drunk as Beverages eg. coffee, cocoa.	Mixed with Food
Morning	_____	_____	_____
Afternoon	_____	_____	_____
Evening	_____	_____	_____

2. What was the main source of this water ? Please check one.

Lake or Stream _____ 'Jerry' Can _____ CHECK ONE ONLY
Water Buffalo _____ Other Sources _____

APPENDIX E

FOOD RECORD CARD FOR VISUAL ESTIMATION TECHNIQUE

MILITARY NUTRITION DIVISION, USARIEM

VISUAL ESTIMATION DATA COLLECTION FORM

SUBJECT NAME: ______________________ MEAL: B L D DATE: __________

SUBJECT NUMBER: __________ DATA COLLECTOR: ______________

FOOD ITEM:	FOOD CODE:	AMOUNT SERVED:	AMOUNT RETURNED:	REASON NOT EATEN:

APPENDIX F

FINAL QUESTIONNAIRE

MRE QUESTIONNAIRE

We would like to ask you some questions about the MRE which you ate during your field training exercise. Your opinions will be very important in determining any changes that will be made in the ration. Your answers will be kept confidential. Please answer honestly and thoughtfully. Please use a #2 pencil.

1. Your name: _____

2. Please indicate your Social Security Number (Last four digits only): _____

3. What is your rank: E-_____ W-_____ O-_____

4. How long have you been in the Armed Services? _____ years _____ months

5. What is your gender? ◯ Male ◯ Female

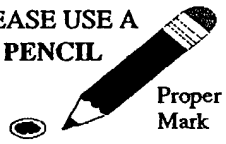
6. What is your age? _____

7. What is your height? _____ft _____in 8. What is your weight _____lbs

9. Are you currently trying to: ◯ lose weight? ◯ gain weight? ◯ neither ?

10. Which ethnic group do you belong to? Please fill in one oval.

◯ American Indian/Alaskan Native
◯ Asian/Pacific Islander
◯ Black/African
◯ Hispanic
◯ White/Caucasian, not of Hispanic origin
◯ Other (please specify):_____



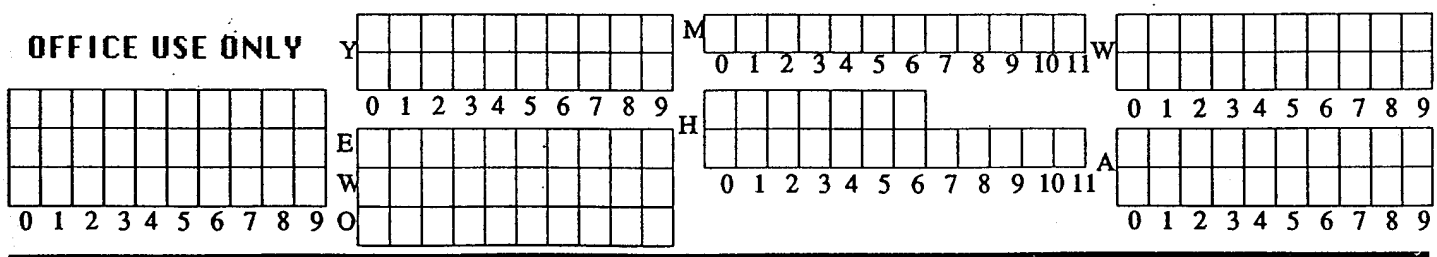
11. In what part of the country did you live the longest before age 16? Please fill in one oval.

◯ New England (ME, NH, VT, MA, CT, RI)
◯ Middle Atlantic (NJ, NY, PA)
◯ South Atlantic (DE, MD, VA, WV, NC, SC, GA, FL, DC)
◯ North Central (OH, IN, IL, MI, WI, MN, IA, MO, ND, SD, NE, KS)
◯ South Central (KY, TN, AL, MS, AR, LA, OK, TX)
◯ Mountain (ID, WY, CO, MT, AZ, NM, UT, NV)
◯ Pacific (WA, OR, CA, AK, HI)
◯ Other (please specify):_____

12. How would you describe your level of activity, during the training exercise?

◯ Heavy daily physical activity
◯ Moderate daily physical activity
◯ Light daily physical activity
◯ Mixed acitivity, day to day

OFFICE USE ONLY



13. We would like your honest evaluation of the MRE items you ate. Using the scale below, please fill in the circle below the number that best describes your opinion of each item. If you never tried an item, fill in the circle under "0".

NEVER TRIED	DISLIKE EXTREMELY	DISLIKE VERY MUCH	DISLIKE MODERATELY	DISLIKE SLIGHTLY	NEITHER LIKE NOR DISLIKE	LIKE SLIGHTLY	LIKE MODERATELY	LIKE VERY MUCH	LIKE EXTREMELY
0	1	2	3	4	5	6	7	8	9

MRE ITEMS

	0	1	2	3	4	5	6	7	8	9
1. Pork w/ Rice and BBQ Sauce	○	○	○	○	○	○	○	○	○	○
2. Corned Beef Hash	○	○	○	○	○	○	○	○	○	○
3. Chicken Stew	○	○	○	○	○	○	○	○	○	○
4. Omelet with Ham	○	○	○	○	○	○	○	○	○	○
5. Spaghetti with Meat Sauce	○	○	○	○	○	○	○	○	○	○
6. Chicken a la King	○	○	○	○	○	○	○	○	○	○
7. Beef Stew	○	○	○	○	○	○	○	○	○	○
8. Ham Slice	○	○	○	○	○	○	○	○	○	○
9. Meatballs with Rice and Sauce	○	○	○	○	○	○	○	○	○	○
10. Tuna with Noodles	○	○	○	○	○	○	○	○	○	○
11. Chicken and Rice	○	○	○	○	○	○	○	○	○	○
12. Escalloped Potatoes with Ham	○	○	○	○	○	○	○	○	○	○
13. Crackers	○	○	○	○	○	○	○	○	○	○
14. Potato au Gratin	○	○	○	○	○	○	○	○	○	○
15. Cheese Spread	○	○	○	○	○	○	○	○	○	○
16. Jelly	○	○	○	○	○	○	○	○	○	○
17. Peanut Butter	○	○	○	○	○	○	○	○	○	○
18. Applesauce	○	○	○	○	○	○	○	○	○	○
19. Fruit Mix	○	○	○	○	○	○	○	○	○	○
20. Peaches	○	○	○	○	○	○	○	○	○	○
21. Pears	○	○	○	○	○	○	○	○	○	○
22. Strawberries	○	○	○	○	○	○	○	○	○	○
23. Brownie	○	○	○	○	○	○	○	○	○	○
24. Cherry Nut Cake	○	○	○	○	○	○	○	○	○	○
25. Chocolate Covered Cookie	○	○	○	○	○	○	○	○	○	○
26. Maple Nut Cake	○	○	○	○	○	○	○	○	○	○
27. Oatmeal Cookie Bar	○	○	○	○	○	○	○	○	○	○
28. Chocolate Nut Cake	○	○	○	○	○	○	○	○	○	○

(Continued on next page)

(Continued)

NEVER TRIED	DISLIKE EXTREMELY	DISLIKE VERY MUCH	DISLIKE MODERATELY	DISLIKE SLIGHTLY	NEITHER LIKE NOR DISLIKE	LIKE SLIGHTLY	LIKE MODERATELY	LIKE VERY MUCH	LIKE EXTREMELY
0	1	2	3	4	5	6	7	8	9

MRE ITEMS	0	1	2	3	4	5	6	7	8	9
29. Grape Beverage	○	○	○	○	○	○	○	○	○	○
30. Orange Beverage	○	○	○	○	○	○	○	○	○	○
31. Lemon-Lime Beverage	○	○	○	○	○	○	○	○	○	○
32. Cherry Beverage	○	○	○	○	○	○	○	○	○	○
33. Cocoa	○	○	○	○	○	○	○	○	○	○
34. Coffee	○	○	○	○	○	○	○	○	○	○
35. Tootsie Roll	○	○	○	○	○	○	○	○	○	○
36. Charms	○	○	○	○	○	○	○	○	○	○
37. M & M	○	○	○	○	○	○	○	○	○	○
38. Caramel	○	○	○	○	○	○	○	○	○	○
39. Gum	○	○	○	○	○	○	○	○	○	○
40. Hot Sauce	○	○	○	○	○	○	○	○	○	○
41. Cream Substitute	○	○	○	○	○	○	○	○	○	○
42. Sugar	○	○	○	○	○	○	○	○	○	○
43. Salt	○	○	○	○	○	○	○	○	○	○
44. Additional Items _____	○	○	○	○	○	○	○	○	○	○
45. _____	○	○	○	○	○	○	○	○	○	○
46. _____	○	○	○	○	○	○	○	○	○	○

14. Do you think any food or beverages should be DROPPED from the MRE?

○ YES ○ NO

If YES, please list the item(s). _____

_____

_____

15. Do you think any food or beverages should be ADDED to the MRE?

○ YES ○ NO

If YES, please list the item(s). _____

_____

_____

44 0 1 2 3 4 5 6 7 8 9 45 0 1 2 3 4 5 6 7 8 9 46 0 1 2 3 4 5 6 7 8 9 15 0 1 2 3 4 5 6 7 8 9

16. For the following questions, use the scale below to indicate your opinion of the MRE.

Never Tried	Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
0	1	2	3	4	5	6	7	8	9

How much did you like or dislike the APPEARANCE of the MRE as a whole?

	0	1	2	3	4	5	6	7	8	9
MRE	○	○	○	○	○	○	○	○	○	○

How much did you like or dislike the VARIETY OF FOODS?

	0	1	2	3	4	5	6	7	8	9
MRE	○	○	○	○	○	○	○	○	○	○

OVERALL, how much did you LIKE the rations?

	0	1	2	3	4	5	6	7	8	9
MRE	○	○	○	○	○	○	○	○	○	○

17. Please use the following scale to rate the PORTION SIZES of the following MRE items?

MUCH TOO SMALL	SOMEWHAT TOO SMALL	JUST RIGHT	SOMEWHAT TOO LARGE	MUCH TOO LARGE
1	2	3	4	5

	1	2	3	4	5
Entrees (main dish)	○	○	○	○	○
Starches (potato, crackers)	○	○	○	○	○
Spreads	○	○	○	○	○
Fruits	○	○	○	○	○
Desserts	○	○	○	○	○
Beverages	○	○	○	○	○
Candy	○	○	○	○	○

18. How many MRE meals did you usually eat each day?

○ a. One
○ b. Two
○ c. Three
○ d. More than three

19. How often did you have time to eat your MRE meal?

NEVER	SOMETIMES	OFTEN	USUALLY	ALWAYS
1	2	3	4	5
◯	◯	◯	◯	◯

20. Did you eat any food during this exercise other than the rations provided? ◯ YES ◯ NO

If YES, please list the foods, how much you ate of each, and how often you ate them.

FOOD	HOW MUCH	HOW MANY TIMES

21. What do you like most about the MRE?

22. What do you like the least about the MRE

23. Do you have any other comments about the MRE?

APPENDIX G

NEUROPHYSIOLOGICAL SYMPTOMS CHECKLIST

NEUROPHYSIOLOGICAL SYMPTOMS CHECKLIST

US ARMY RESEARCH INSTITUTE OF ENVIRONMENTAL MEDICINE

NAME:_____ SUBJECT NO:____ DATE:_____

Use the checklist below to indicate how you have been feeling over the last 24 hours. Circle the number that best describes how well the word applies to you.

	a little		somewhat		extremely
achy	1	2	3	4	5
afraid	1	2	3	4	5
alert	1	2	3	4	5
attentive	1	2	3	4	5
bored	1	2	3	4	5
challenged	1	2	3	4	5
cheerful	1	2	3	4	5
cold	1	2	3	4	5
competent	1	2	3	4	5
confused	1	2	3	4	5
constipated	1	2	3	4	5
coordinated	1	2	3	4	5
depressed	1	2	3	4	5
diarrhea	1	2	3	4	5
dizzy	1	2	3	4	5
encouraged	1	2	3	4	5
energetic	1	2	3	4	5
excited	1	2	3	4	5
forgetful	1	2	3	4	5
happy	1	2	3	4	5
headache	1	2	3	4	5
hot	1	2	3	4	5
hungry	1	2	3	4	5
interested	1	2	3	4	5
irritated	1	2	3	4	5
nervous	1	2	3	4	5
optimistic	1	2	3	4	5
overworked	1	2	3	4	5
powerful	1	2	3	4	5
relaxed	1	2	3	4	5
rested	1	2	3	4	5
restless	1	2	3	4	5
shaky	1	2	3	4	5
sleepy	1	2	3	4	5
stiff	1	2	3	4	5
stomach upset	1	2	3	4	5
stomach gas	1	2	3	4	5
strong	1	2	3	4	5
thirsty	1	2	3	4	5
tired	1	2	3	4	5

APPENDIX H

ACCESSORY PACKET QUESTIONNAIRE

1. In most field exercises, how important is it to have the following items in the MRE Accessory Packet? Check one response per item:

ITEM	NOT IMPORTANT	SLIGHTLY IMPORTANT	MODERATELY IMPORTANT	VERY IMPORTANT
matches				
toilet tissue				
towelettes				
gum				
instant coffee				
creamer				
sugar				
salt				

2. How do you prefer to have the matches, toilet tissue, and towelettes issued? Circle one response:

a. Issued in the MRE Packet

b. Issued separately from the MRE

APPENDIX I

FLAMELESS RATION HEATER (FRH) QUESTIONNAIRE

FLAMELESS RATION HEATERS (FRH)

1: How many times per day did you use FRH to heat MRE entrees?

a. 0 b. 1 c. 2 d. 3 e. 4 or more

FOR QUESTIONS 2-6, CIRCLE YOUR RESPONSE:

2. After heating with the FRH, what was the temperature of the MRE entree?

cold cool neither warm or cool warm hot

3. How does the MRE entree taste when you've heated it with the FRH, compared to eating the MRE entree cold:

much worse | moderately worse | slightly worse | about the same | slightly better | moderately better | much better

4. Please indicate how slow or fast you felt it took to heat the MRE entree.

very slow | moderately slow | slightly slow | neither slow nor fast | slightly fast | moderately fast | very fast

5. How easy or difficult is it to use the FRH to heat the MRE entree?

very difficult | moderately difficult | slightly difficult | neither difficult nor easy | slightly easy | moderately easy | very easy

6. Please rate the overall acceptability of using the FRH in the field.

very bad | moderately bad | slightly bad | neither bad nor good | slightly good | moderately good | very good

7. Were any of the following a problem for you while using the FRH to heat the MRE entree? Check ONE for each item.

	NOT A PROBLEM	SLIGHT PROBLEM	MODERATE PROBLEM	LARGE PROBLEM
a. Adding water to bag	_____	_____	_____	_____
b. Burning hands	_____	_____	_____	_____
c. FRH not heating up	_____	_____	_____	_____
d. Smell produced during heating	_____	_____	_____	_____
e. Water spilling out of plastic bag	_____	_____	_____	_____
f. Residue caused by heating process	_____	_____	_____	_____

8. If an FRH were packaged with each MRE, how often do you think you would use it to heat the MRE entree?

never almost never sometimes almost always always

9. If FRH were issued separately from the MRE, but available for your use, how often do you think you would use the FRH to heat your MRE entree?

a. never b. heat one out of three entrees c. heat one out of two entrees d. heat every entree

10. For what reasons would you NOT use the FRH to heat MRE entrees. Circle all reasons that apply.

a. Question does not apply, I would almost always use the FRH
b. Too complicated
c. Doesn't heat well
d. Not enough time to use
e. Wouldn't waste water for heating
f. Produces bad smell
g. Creates a mess
h. Prefer other methods of heating (Specify:_____)
i. Other (Specify:_____)

11. If you were not able to use the FRH to heat the MRE entree, would you save it for later use or throw the FRH away? Circle one response.

a. save it b. throw it away

APPENDIX J

MRE XII MENUS AND COMPONENTS

Menu 1	Menu 2	Menu 3	Menu 4	Menu 5	Menu 6	Menu 7	Menu 8	Menu 9	Menu 10	Menu 11	Menu 12
Pork w/Rice TS-8oz	Corned BF Hsh TS-8oz	Chicken Stew TS-8oz	Omelet w/ Hm TS-6oz	Spagh w/ Meat Sce TS-8oz	Chicken ala King TS-8oz	Beef Stew TS-8oz	Ham Slice TS-4.3oz	Meatball in Tom Sce TS-8oz	Tuna w/ Noodles TS-8oz	Chicken w/ Rice TS-8oz	Esc Pot w/ Ham TS-8oz
Apple Sauce TS	Fruit TS	Fruit TS	Potato Au Grat TS-5oz		Fruit TS		Potato Au Grat TS-5oz	Fruit TS		Fruit FD	Apple Sce TS
	Oatmeal Cookie Bar		Oatmeal Cookie Bar	Maple Nut Cake		Cherry Nut Cake	Brownie Choc Cvd	Cookie Choc Cvd	Choc Nut Cake	Cookie Choc Cvd	Brownie Choc Cvd
Jelly	Jelly	Peanut Butter	Cheese Spread	Cheese Spread	Peanut Butter	Peanut Butter	Jelly	Peanut Butter	Cheese Spread	Cheese Spread	Jelly
Cracker	Cracker	Cracker	Cracker	Cracker	Cracker	Cracker	Cracker	Cracker	Cracker	Cracker	Cracker
				Candy*	Candy*			Candy*		Candy*	
Cocoa	Cocoa	Cocoa	Cocoa		Cocoa		Cocoa				Cocoa
Bev Base	Bev Base	Bev Base	Bev Base	Bev Base	Bev Base	Bev Base	Bev Base	Bev Base	Bev Base	Bev Base	Bev Base
Hot Sce	Hot Sce	Hot Sce	Hot Sce	Hot Sce	Hot Sce	Hot Sce	Hot Sce	Hot Sce	Hot Sce	Hot Sce	Hot Sce
Spoon	Spoon	Spoon	Spoon	Spoon	Spoon	Spoon	Spoon	Spoon	Spoon	Spoon	Spoon
Acc Pkt B	Acc Pkt B	Acc Pkt B	Acc Pkt B	Acc Pkt A	Acc Pkt A	Acc Pkt A	Acc Pkt A	Acc Pkt A	Acc Pkt A	Acc Pkt A	Acc Pkt A

Accessory Packet A: Coffee, Cream Sub, Sugar, Salt, Gum, Matches, Tissue Towelette
Accessory Packet B: Coffee, Cream Sub, Sugar, Salt, Gum, Matches, Tissue Towelette, Candy (Vanilla Caramels, Tootsie Rolls, Heat Stable Chocolate Bar)
FD -Freeze Dried
TS - Thermostabilized
* - Charms, Heat Stable M&Ms

APPENDIX K

30-DAY A RATION MENU

STANDARD BREAKFAST MENU - available each day		
Bread, one or more	**Meat**, one or more	**Fruit**, one or more
white b. or toast	creamed ground beef	apples
wheat b. or toast	bacon	oranges
rye b. or toast	sausage patty	bananas
biscuits	ham	cantalope
french toast	**Spreads**	grapes
pancakes	syrup	**Juice or J. Drink**
Cereals	jelly	orange juice
grits	margarine	grape juice
oatmeal	**Condiments**	apple juice
assorted, dry	sugar	tomato juice
	creamer	beverage base
	salt	pineapple punch
		Beverages
		iced tea
		coffee
		2% white milk
		1% chocolate milk

STANDARD LUNCH MENU - MRE every day

STANDARD DINNER MENU ITEMS - available with each meal*		
Bread, one or more	**Fruit**, one or more	**Beverages**
white	apples	beverage base
wheat	oranges	pineapple punch
rye	bananas	ice tea (sw or unsw)
rolls	cantalope	2% white milk
biscuits	grapes	1% chocolate milk
Spreads	applesauce	coffee
catsup	**Salad Dressings**	**Condiments**
margarine	french	creamer
mayonnaise	italian	sugar
mustard	thousand island	salt

* in addition to specific day's dinner menus

DINNER MENUS

Day 1 October 5, 1991	Day 2 October 6, 1991	Day 3 October 7, 1991
Beef Noodle Soup Baked Chicken Oven Browned Potatoes Lyonaise Potatoes Stewed Tomatoes Tossed Salad Cookies Chocolate Cake w/ Frosting	Tomato Vegetable Soup Roast Turkey Barbecued Chicken Candied Sweet Potatoes Green Beans Spring Salad	Hamburger/Cheeseburger Grilled Cheese Sandwich Grilled Ham and Cheese Roast Turkey w/ Gravy Corn Chips/Potato Chips French Fries Baked Beans Green Beans Spring Salad Brownies

Day 4 October 8, 1991	Day 5 October 9, 1991	Day 6 October 10, 1991
Tomato Vegetable Soup Spaghetti w/ Meat Sauce Ravioli Grated Cheese Garlic Bread Broccoli Corn Tossed Salad Vanilla Pudding Brownies Yellow Cake w/ Chocolate Frosting	Beef Noodle Soup Veal Steaks Spaghetti w/ Meat Sauce Grated Cheese Garlic Bread Paprika Buttered Potaotoes Broccoli Corn Spring Salad Yellow Cake w/ Chocolate Frosting	Beef Noodle Soup Salisbury Steak Beef Pot Pie w/ Biscuits Gravy Mashed Potatoes Steamed Rice Green Beans Carrots w/ Peas Tossed Salad Gelatin
Day 7 October 11, 1991	**Day 8 October 12, 1991**	**Day 9 October 13, 1991**
Beef Noodle Soup Baked Chicken Fried Chicken Chicken Gravy Paprika Potatoes Fried Rice Carrots Succotash Tossed Salad Gelatin	Beef Vegetable Soup Roast Beef Gravy Mashed Potatoes Carrots Country Style Tomato Salad	Chicken Soup Roast Turkey Cranberry Sauce Roast Beef Gravy Mashed Potatoes Corn Carrots Garden Vegetable Salad
Day 10 October 14, 1991	**Day 11 October 15, 1991**	**Day 12 October 16, 1991**
Tomato Vegetable Soup Pepper Steak Swiss Steak Roast Turkey Garlic Bread Gravy Steamed Rice Mashed Potatoes Carrots Peas Tossed Salad	Beef Noodle Soup Roast Beef Gravy Potatoes, boiled Stewed Tomatoes Green Beans Tossed Salad Potato Salad Strawberry Creme Cookies	Chili Con Carne Barbecued Beef Barbecued Ham on Roll Steamed Rice Carrots Green Beans Tossed Salad Gelatin Cherry/Apple Pie Vanilla Pudding

Day 13 October 17, 1991	Day 14 October 18, 1991	Day 15 October 19, 1991
Tomato Vegetable Soup Steak w/ Onions and Mushrooms Baked Potato Sour Cream Broccoli Corn Apple, Celery and Raisin Salad Chef Salad Pineapple upside-Down Cake	Tomato Vegetable Soup Braised Beef w/ Noodles Broccoli Carrots w/ Ham Tossed Salad Pineapple Upside-Down Cake Chocolate Cake w/ Frosting	Chicken Noodle Soup Roast Turkey Cranberry Sauce Gravy Baked Ham and Pineapple Mashed Potatoes Green Beans Spring Salad Choclate Cake w/ Frosting
Day 16 October 20, 1991	Day 17 October 21, 1991	Day 18 October 22, 1991
Beef Noodle Soup Roast Beef Baked Chicken Fried Chicken Chicken Gravy Steamed Rice Macaroni and Cheese Corn w/ Ham Green Beans Green Beans w/ Ham Tossed Salad Macaroni Salad Stawberry Creme Cookie	Chicken Noodle Soup Braised Pork Chops Barbecued Chicken Ham Slices in BBQ Sauce Brown Gravy Mashed Potatoes Carrots Lima Beans Tossed Salad	Chicken Noodle Soup Spaghetti w/ Meat Sauce Ravioli Parmesan Cheese Garlic Bread Broccoli Succotash Tossed Salad Yellow Cake w/ Chocolate Frosting Yellow Cake w/ Butter Creme Frosting
Day 19 October 23, 1991	Day 20 October 24, 1991	Day 21 October 25, 1991
Chicken Noodle Soup Breaded Veal Patty Spaghetti w/ Meat Sauce Parmesan Cheese Brown Gravy Potatoes, boiled Broccoli Corn Tossed Salad Yellow Cake w/ Butter Creme Frosting Yellow Cake w/ Chocolate Frosting	Chicken Noodle Soup Sailsbury Steak Beef Ravioli Brown Gravy Mashed Potatoes Peas Carrots Tossed Salad Yellow Cake w/ Chocolate Frosting	Beef Vegetable Soup Baked Chicken Barbecued Chicken Fried Chicken Pork Chops Salisbury Steak Gravy Green Beans w/ Ham Succotash Fried Rice Buttered Potatoes Tossed Salad

Day 22 October 26, 1991 Tomato Vegetable Soup Roast Beef Barbecued Chicken Gravy Seasoned Potatoes Succotash Glazed Carrots Tomato Salad	Day 23 October 27, 1991 Vegetable Soup Roast Turkey Roast Beef Gravy Mashed Potatoes Steamed Rice Cornbread Stuffing Corn Green Beans Tossed Salad Yellow/Chocolate Cake w/ Chocolate Frosting	Day 24 October 28, 1991 Vegetable Soup Roast Turkey Turkey Nuggets Pepper Steak Gravy Garlic Bread Steamed Rice Mashed Potatoes Corn Carrots Tossed Salad Chocolate Cake
Day 25 October 29, 1991 Beef Noodle Soup Roast Beef Lasagna Veal Parmesan Gravy Garlic Bread Oven Browned Potatoes Mashed Potatoes Succotash Green Beans Tossed Salad Ham Salad Deviled Eggs Gelatin	Day 26 October 30, 1991 Chili Swiss Steak Roast Beef Brown Gravy Steamed Rice Mashed Potatoes Green Beans Carrots Chef's Salad Creme Sandwich Cookies	Day 27 October 31, 1991 Tomato Vegetable Soup Baked Chicken Fried Chicken Cheese Ravioli Gravy Steamed Rice Mashed Potatoes Succatash Green Beans Spring Salad Gelatin Creme Sandwich Cookie
Day 28 November 1, 1991 Tomato Vegetable Soup Braised Beef w/ Noodles Chili Steamed Rice Broccoli Corn Chef Salad Chocolate Cake w/ Frosting	Day 29 November 2, 1991 Beef Noodle Soup Fried Chicken Cheeseburger Oven Browned Potatoes Potato Chips/Corn Chips Stewed Tomatoes Corn Peas Tossed Salad Chocolate Cake w/ Frosting Creme Sandwich Cookies	Day 30 November 3, 1991 Tomato Vegetable Soup Roast Turkey Cranberry Sauce Roast Beef Beef Stew Gravy Candied Sweet Potatoes Mashed Potatoes Green Beans Corn Spring Salad

APPENDIX L

NUTRITIVE VALUES OF MRE XII

RECORD OF NUTRITIVE VALUES MRE XII FINALFILE 10/15/91

TOTALS	Water (g)	Protein (g)	Fat (g)	Ash (g)	Calcium (mg)	Phos (mg)	Iron (mg)	Sodium (mg)	Potass (mg)	Magnesium (mg)	NaCl (g)	Zinc (mg)	Cholestrol (mg)
NR.													
1	262.20	44.30	46.76	8.42	458	633	6.54	1324	1626	112	3.08	4.59	79
2	179.19	48.15	45.69	8.41	456	614	7.09	1550	1389	125	3.47	7.30	105
3	298.70	44.12	50.96	8.72	477	792	4.76	1349	1837	180	2.79	2.27	43
4	269.20	49.35	68.92	11.96	724	1387	6.10	2613	1450	134	5.07	2.20	406
5	210.11	46.76	60.40	9.61	644	741	7.02	2110	1079	123	4.64	3.41	98
6	180.21	56.81	55.67	9.36	476	753	5.13	1652	1598	179	3.30	2.51	84
7	193.71	57.03	55.90	8.37	413	579	6.92	1773	1219	160	3.89	0.90	138
8	215.82	44.23	45.92	10.82	515	1125	5.29	2459	1524	128	5.13	2.88	107
9	150.33	59.54	61.93	10.04	451	690	8.26	1967	1560	185	4.43	7.47	66
10	211.30	51.58	56.11	6.90	548	716	5.27	1540	624	106	3.01	0.90	111
11	190.76	49.99	53.94	7.63	556	765	5.07	1822	866	104	3.62	2.93	130
12	295.25	38.19	41.63	8.72	435	757	5.51	1717	1498	127	3.62	2.82	66
MEAN	221.40	49.17	53.65	9.08	513	796	6.08	1823	1356	139	3.84	3.35	119
MEAL REQUIREMENTS													
1/3 AR 40-25		33.33	53.3		267	267	6.0	1667-2334	625-1825	133		5.0	

	A (IU)	Carotene (mg)	Total A (IU)	C (mg)	B1 (mg)	B2 (mg)	Niacin (mg)	B6 (mg)	Folacin (mcg)	B12 (mcg)	E (mg)	CHO (g)	Calories	Weight (g)
NR.														
1	2940	0.004	2950	91	2.66	1.10	10.4	1.83	47	0.86	3.97	186.86	1345	549
2	3080	0.069	3200	135	2.40	1.02	10.2	1.86	88	1.09	4.53	206.09	1428	488
3	4640	1.948	7890	135	3.23	0.98	18.9	1.85	124	1.09	8.44	176.21	1340	579
4	6920	0.058	7020	116	3.53	1.37	8.9	3.16	85	0.92	5.51	172.33	1507	572
5	2910	0.578	3870	69	2.18	1.16	10.6	2.07	63	0.79	6.41	166.94	1398	494
6	4630	0.286	5110	165	3.22	1.08	16.9	1.76	68	0.86	3.72	159.51	1366	462
7	1710	1.267	3820	78	2.03	1.01	12.9	0.75	74	1.70	6.74	141.02	1295	456
8	3800	0.055	3900	91	3.02	1.15	10.4	2.06	25	0.76	4.33	162.17	1239	478
9	2200	0.059	2300	119	2.39	1.04	16.5	0.99	71	1.02	9.07	174.52	1494	456
10	3510	0.000	3510	67	2.19	0.92	11.9	2.01	55	0.56	5.96	129.94	1231	456
11	3400	0.000	3400	69	2.46	0.99	16.8	2.43	113	0.33	2.70	144.05	1262	446
12	3660	0.004	3670	92	3.07	1.06	11.6	2.19	61	0.63	3.44	186.39	1273	570
MEAN	3617	0.361	4220	102	2.70	1.07	13.0	1.91	73	0.88	5.40	167.17	1348	500
MEAL REQUIREMENTS														
1/3 AR 40-25			1670	20	0.60	0.73	8.0(N.E.)	0.73	133	1.0	3.3	146.7	1200	

Percent of Calories from: Protein - 15 Percent
Fat - 36 Percent
CHO - 50 Percent

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